Foreign Investment, Technology and Economic Growth

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Preface

THIS RESEARCH PROJECT was inspired by a number of high profile foreign takeovers of Canadian high-technology firms, including the takeover of Connaught Laboratories by Institut Merieux. The number of takeovers of high-tech Canadian-owned firms represents less than five percent of the cases reviewed by Investment Canada, but these cases have accounted for a disproportionately large part of these review activities and effort. This is not surprising, given the public controversy that typically accompanies such takeovers. Critics often attribute the relatively poor R&D record in Canada to the high levels of foreign control in this economy. However, the evidence tends to show the opposite — foreign investment leads to important transfers of technology and usually to significant productivity gains.

The race for the technological frontier is at the centre of an emerging globalization process. Today's global corporations not only invest in international markets where they desire to trade, but also transfer technology to these markets and conduct R&D where there are technological advantages. While much has already been written on foreign investment and technology, it was felt necessary to return to fundamentals in light of globalization and the changing relationships among the economic factors at play. This work was considered all the more important since Canada has traditionally depended on international trade and investment for much of its prosperity.

In January 1990, distinguished academics and profesisonals from Canada and abroad were invited to prepare papers on the topic of "Foreign Investment, Technology and Economic Growth". The papers were presented at an Authors' Conference in Ottawa on September 6 and 7, 1990, and later revised in light of comments by discussants and participants. The revised papers, together with the Discussants' comments and the Rapporteur's report, are presented in this volume, the first in the Investment Canada Research Series. Don McFetridge, Carleton University, served as General Editor, and his introduction immediately follows.

The Investment Canada Research Series has been developed with three main objectives:

- to advance research on international investment in Canada and abroad, based on the highest academic scholarship;
- to foster a better understanding among Canadians of globalization and the vital role played by international investment; and,
- to identify investment policy and research issues requiring the attention of governments and particularly of Investment Canada, which has responsibilities for promoting, reviewing and monitoring international investment.

The research assembled in this volume is mainly the product of work undertaken by outside researchers. However, Investment Canada staff managed the project and throughout offered comments on the papers. As is the case with the Investment Canada Working Paper Series (these papers available on request from the Agency), the views expressed in these research studies do not necessarily reflect those of Investment Canada or the federal government.

I would like to take this opportunity to thank all participants in the research effort, and especially Don McFetridge, for their work. I know that it will be of interest to a wide range of Canadians.

MICHAEL WILSON
MINISTER RESPONSIBLE FOR
INVESTMENT CANADA

Introduction

THE APPROPRIATE PUBLIC POLICY stance toward foreign acquisitions of domestic high-tech businesses has been a politically contentious issue in Canada for many years. It is now attracting an increasing amount of attention in other industrialized countries as well. While the political pressures to intervene, to present, or to alter the terms of a proposed foreign acquisition of a domestic business can be intense, the principles and empirical evidence that might provide guidance as to how and when to intervene productively are not well-known.

The role of Investment Canada is to encourage foreign direct investment in Canada and to monitor foreign acquisitions of Canadian businesses to ensure that such transactions are of net benefit to Canada. In order to increase public awareness and understanding of how and when a national investment monitoring agency can increase the domestic benefits derived from foreign investment in domestic high-tech firms, Investment Canada commissioned eleven studies on this subject. The results of those studies were presented as academic papers at an authors' conference in Ottawa on September 6 and 7, 1990. The papers were revised in the light of comments from invited discussants and other conference participants. The revised papers, together with many of the discussants' comments, and an overall commentary by Richard Lipsey, are presented in this volume.

Among the more important questions addressed by the papers are:

- have foreign takeovers of domestic high-tech firms been an important phenomenon in Canada?
- does a change in the nationality of the ownership of a firm imply a change in its behaviour, specifically with respect to technological activities?
- does a change in the technological capacity of one firm affect the innovative capabilities of other firms and individuals in the economy?
- does an investment monitoring agency have any leverage over foreign investors in high-tech firms?

The papers by Baldwin and Gorecki, and Globerman address the first question. They conclude that, although there have been a number of highly publicized takeovers of Canadian high-tech firms by foreign interests, this phenomenon has been relatively unimportant in terms of the number of takeovers and the value added involved.

The second question is addressed in one way or another by virtually all the papers in the volume. The consensus is that the substitution of foreign for domestic control changes the way firms behave, but not in any systematic fashion.

With respect to the much-discussed tendency of foreign-owned firms to locate their R&D at home, the evidence in the Pavitt and Patel, the Cantwell, and the Blomström papers is that there is a bias toward "home" R&D but that its strength depends on the size and technological characteristics of the home country and the other markets for a firm's products, and other sources of a firm's technology. There is, as yet, no systematic evidence that centralization also occurs when there is a change in control. We do not yet know whether the substitution of foreign for domestic control reduces local R&D below what it would otherwise have been. (The impression of the authors and most of the discussants is that there is probably no reduction.) Possible reasons are: the innovative capability acquired is embedded in the local organization and local networks, and the acquiring firm's assets are often complementary, involving marketing and/or production expertise rather than a substitute innovative capability.

The third question is addresed by the Bernstein paper as well as those by Harris, Blomström, Globerman and DeBresson et al. They conclude that there is a large gap between private and social rates of return on domestic R&D. This implies that a reduction in local R&D by one firm does reduce the innovative capability of others in the economy. Individual countries may, therefore, benefit from R&D-shifting policies pursued by their governments or by government-controlled firms. Individual countries may also benefit from policies designed to forestall this shifting of R&D.

Despite the effort that has gone into attempts to measure the social rate of return on R&D, much remains to be learned. Pierre Mohnen pointed out in his discussion that the domestic rate of return on imported R&D is also very high. This implies that on balance, the loss is not as great when R&D is shifted out of the country if the offsetting value of imported R&D is taken into account.

With respect to policy leverage, the issue is whether commitments to local R&D and the like, negotiated by Investment Canada, are incremental and, if so, whether they come out of the surplus of the foreign acquiring firm or serve merely to reduce the return to domestic entrepreneurs and shareholders cashing out. The evidence in the papers by Teece, and Globerman and in the discussion by Tom Kierans, is that foreigners have paid pretty much their reservation price for Canadian and American high-tech acquisitions and that whatever local R&D or other commitments were made, they were within what was intended, in any case.

The impression is that more policy leverage can be gained by encouraging domestic human capital formation (which, in turn, is likely to attract R&D activities) than by extracting concessions from foreign investors, although in his commentary Richard Lipsey maintains that there have been, and will continue to be, important exceptions which justify a continued monitoring capability over foreign investment.

DONALD G. McFETRIDGE
JULY, 1991

Richard G. Harris
Simon Fraser University

1

Strategic Trade Policy, Technology Spillovers and Foreign Investment

INTRODUCTION

THE PURPOSE OF THIS PAPER is to review the literature on strategic trade policy with respect to the issue of foreign direct investment and its implications. Further, I have undertaken to review the arguments offered by modern trade theorists with respect to foreign takeovers of high-technology industries. There is a substantial body of literature on foreign direct investment (FDI), which includes exhaustive analyses of multinational firms(MNEs) and strategic trade policy.[1] Surprisingly, there has been little intersection of the writing in these two areas. This is surprising because both areas appeal to imperfect product market theory. On the other hand the literature on MNEs and strategic trade policy are really quite different from one another in their basic approaches. This is obvious in the Canadian policy literature that emphasizes the role of the multinationals. While most of this paper deals with the modifications necessary to the strategic trade policy arguments when there is substantial foreign investment, I also contend that traditional views on foreign investment are changed little for a small open economy such as Canada even if the arguments put forward in favour of strategic trade policy for the larger countries are accepted at face value.

The heart of the strategic trade policy argument revolves around the possible existence of oligopoly rents due to barriers to entry. The barriers to entry may be large economies of scale in production or distribution, or substantial sunk costs present in the form of R&D expenditures. Either may give rise to small numbers competition and oligopoly rents which persist over the long term because of the inability of potential entrants to secure profitable entry into the industry. In an international market, but with the firms' owners concentrated geographically, each government has incentives to take policy actions which attempt to shift rents toward those firms owned by its citizens-voters. Much of the literature is concerned with the various strategies governments can adopt in an attempt to shift these rents, and the complications that arise when governments interact strategically with other governments and large firms. If an oligopolistic firm producing in the home country is owned and controlled by foreigners, the question of who receives the rents becomes crucial.

In the Canadian policy literature on foreign direct investment (FDI) much of the concern has been with two issues:[2] in extractive industries, resource rents should be captured at home rather than by foreign shareholders; in manufacturing industries, technology should be transferred efficiently and at a fair price from the foreign developers of that technology to the home country. Foreign direct investment is probably the most important device by which technology transfers occur, and therefore FDI is seen as a poor substitute for both portfolio investment and other arm's-length transactions such as technology licensing. More recently, however, the perspective on FDI has shifted to those firms that develop technology indigenously; does foreign ownership of such firms mean that the technology will be exploited abroad rather than at home? If so, does the home country obviously lose in these circumstances relative to a situation in which the innovating firm is domestically owned? This shift of emphasis from inward technology transfers to outward technology flows is relatively new for Canada but is reminiscent of the 1960s debate in the United States on American multinationals accused of exporting jobs abroad.[3] In the second part of this paper I consider what new implications might be drawn from strategic trade policy theory as it relates to this type of argument.

This paper is limited in its scope by an underlying assumption that what motivates the problem is the presence of market power on the part of firms in their final product markets, and political power on the part of governments that choose to intervene. My analysis is therefore limited in that it does not try to explain the reasons for the existence of transnational or multinational firms; the firm-specific advantages, including the mitigation of transactions costs through internalization (which are commonly used as reasons for the existence of multinationals) are assumed as given in the analysis.

An entirely different set of questions revolves around the externalities issue focussing on technology transfer between countries, and spin-offs from technologically intensive industries. That is, in the presence of incomplete markets and incomplete contracts, does the question of the national ownership of a firm have any policy significance? I contend that this debate is closely related to the debate on the appropriate trade theory paradigm for explaining international differences in real income. Many now question the traditional Heckscher-Ohlin view of trade and income.[4] The North-South product cycle of trade associated with Raymond Vernon (1966) is considered by many — myself included — to offer a far more realistic view of international trade and the sources of productivity differences between nations in manufacturing and service industries.[5] The essential building block of these theories is the assumption that the process of technology transfer is characterized by both spillovers and lags in international diffusion which are quantitatively significant.

In addition, market structure plays a much more prominent role in these theories than in factor endowment theories, providing a link with the strategic trade policy literature. In the last two sections of this paper I bring this view of trade and technology to bear on the question of foreign ownership of technologically progressive industries in a smaller industrialized country such as Canada. The policy questions addressed in these sections are less strategic than structural in nature. That is, does foreign ownership of such industries contribute to or hinder the pace of economic growth? I contend that there are two distinct aspects to this question — first, the role of innovation and international diffusion as a source of international differences in factor returns; second, the role of spillovers from R&D activity which are of national benefit but are geographically mobile as a consequence of decisions by corporations to relocate their own activities.

The paper is organized as follows: beginning with a brief review of the case for strategic trade policy, including its theoretical limitations and why it remains a popular and powerful idea in the policy arena. Next, I consider the issue of strategic trade policy in export industries, assuming the exporting firm is foreign-owned. I then examine the role of foreign monopoly rents generated in domestic markets, followed by a discussion of the role of foreign firms in determining the extent of competition in the domestic market. In the next section import competition and FDI as substitutes are discussed, followed by a consideration of efficiency-enhancing horizontal mergers when the merger involves takeover by a foreign firm. I then discuss the effect of modern protectionism in the form of quotas and voluntary restraint agreements on the cost/benefit calculus of foreign ownership. This is followed by brief review of the policy debate on foreign takeovers of domestic-owned technologically intensive firms. The product cycle view of trade and income is reviewed next and used to address the question of innovation rents and who receives them — does foreign ownership matter? Finally, I address the case of locational mobile spillovers from R&D activity and, in the last section, offer some conclusions.

STRATEGIC TRADE POLICY: A REVIEW

TO DATE, THE LITERATURE HAS FOCUSSED almost entirely on the cases in which firms are national — meaning that production occurs in the home country and that 100 percent of the equity is held by citizens and voters of the home country. In addition, government is assumed to be interested in maximizing national welfare defined as the sum of consumer surplus, plus producer surplus, plus net government revenues in the home country. In international competition, governments wish to transfer economic profits or monopoly rents from foreign firms to domestic firms. This observation is attributable to Brander and Spencer (1985) who demonstrated in a simple model of international oligopolistic competition that it is optimal for the home government to subsidize export sales; the purpose of the subsidy is not to increase foreign sales *per se*, but rather to reduce the sales of the competing foreign firm, thus shifting the monopoly rents toward the home firm. This idea has been extremely important in demonstrating the weakness of the traditional case for trade liberalization and free trade in the presence of large scale international oligopoly. As the strategic trade policy literature developed, however, the case for intervention seemed much weaker than it first appeared. Several of the more important problems are:[6]

1) The sensitivity of government policy to industry conduct. In order for government to choose correct policies it must understand perfectly the strategic nature of firm conduct within an industry. If firms compete on price rather than productive capacity, then the optimal policy is to tax exports rather than to subsidize. Sensitivity is a general theme of this literature, implying that governments must have extremely detailed knowledge of industry behaviour to intervene correctly.
2) Supply conditions in the industry. In the original models it was assumed that there were no supply constraints so it would be possible to shift resources into an industry at constant opportunity cost. If supply constraints reduce this elasticity of supply, the case for encouraging the industry through subsidy or protection is substantially reduced.
3) Long-run barriers to entry. Most of this literature has been concerned with industries that have substantial entry barriers, even in the long run. If entry occurs over the longer run in response to high industry profitability then many of the conclusions are no longer valid.
4) Sub-optimality of strategic trade policy in the face of retaliation. The most glaring indictment of strategic trade policies however, is the argument that: if country A is hurt by the strategic trade polices of country B, and country A retaliates in kind, the resulting outcome will be inferior to no intervention by either government. That is, strategic trade policies are inherently beggar-thy-neighbour policies in many respects.

This point is invariably demonstrated in symmetrical two-country models using the prisoner's dilemma characterization of the game the two national governments are assumed to play.

Thus the theoretical case for an interventionist trade-industrial policy based on the notion that international tradeable goods industries are oligopolistic appeared not as clear as some of the enthusiasts imagined. Indeed, it is surprising that the support for these ideas remains as strong as it appears to be, given the criticisms which have been levelled at strategic trade policy.

While the support for strategic trade policy may be self-serving in some industries, there are several reasons why the basic ideas put forward in this literature are not likely to be dismissed easily. First, there is the overwhelming perception that international competition is highly oligopolistic and that it is dominated by extremely large firms in both manufacturing and service industries. In this instance the relevance of perfect competition seems remote at best. Second, there is the enduring opinion (held notably by many U.S.-based public policy commentators) that Japan, particularly, has successfully pursued a strategic industrial policy in these industries using both protection and subsidy to nurture winners in the emerging industries. Third, there have been numerous empirical demonstrations that the simple Prisoner's dilemma characterization of strategic trade policy equilibrium is not always appropriate. With asymmetries between countries either in size, cost structures or demand, unilateral pursuit of an interventionist policy can be superior, even in the event of retaliation to the no intervention equilibrium.[7] The strongest theoretical case against strategic trade policy, therefore, is weaker than the critics thought, but clearly is still practically relevant in many circumstances.

The debate has moved out of the journals and into the policy arena with no clear resolution of the tensions between the laissez-faire/free trade position and the strategic trade policy position of the "industrial policy" activists.

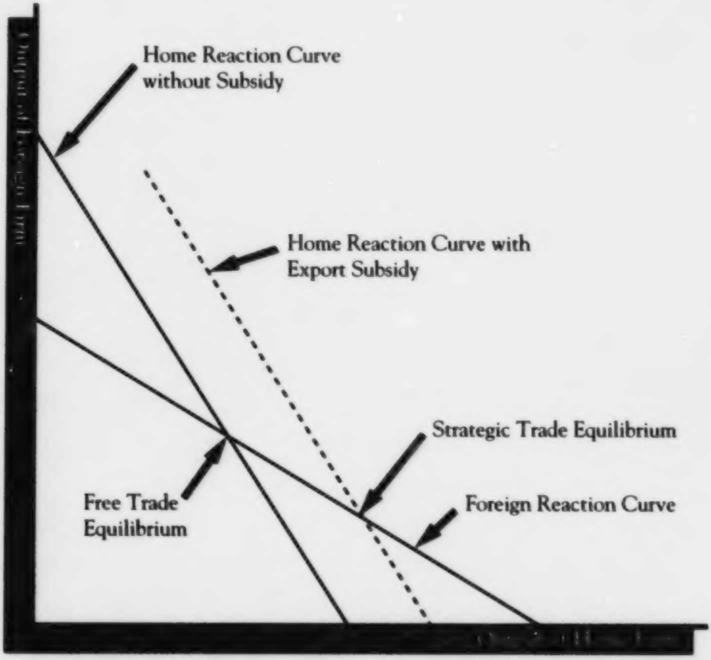
The relevance of this debate for smaller countries has never been very clear. Most small countries do not have national firms with large market shares of the internationally traded manufacturing industries. Rather, smaller countries with successful exporters tend to be in niche markets in which global scale economies are less likely to be important. It is, of course, possible that oligopoly rents exist in these niche markets and therefore the conventional strategic trade policy lessons could be applied to small countries. On the other hand, many small countries have subsidiaries of the large global multinationals (MNEs) that are producing in or otherwise serving the local home market. The strategic trade policy literature has not yet debated the policy implications for the smaller countries. Finally, as international management theorists continually remind us, the large firms are now truly global in that their owners reside in many countries and owe no allegiance to any particular country.[8] In the light of these considerations, how should trade and industrial policy be conducted, given that national profit shifting seems no longer relevant as a policy goal?

EXPORT MARKETS AND FDI

THE FIRST CASE CONSIDERED is closest in spirit to the traditional strategic trade policy literature. The home country is the location of firms that produce for export only and not for the home market. In the case considered most often the home firm is also domestically owned; we now assume instead that the home firm is owned and controlled by foreign equity holders. Throughout most of this paper we assume that firms maximize profits.[9] The foreign-owned firm can be thought of as a subsidiary of a multinational that is involved in the distribution and marketing of an MNE's proprietary product line, or simply as a foreign-owned and -controlled firm selling a product unique to this division of the MNE.

FIGURE 1

STRATEGIC TRADE POLICY WITH INTERNATIONAL DUOPOLY


Output of Foreign Firm
Home Reaction Curve without Subsidy
Home Reaction Curve with Export Subsidy
Strategic Trade Equilibrium
Free Trade Equilibrium
Foreign Reaction Curve

To keep the analysis simple, imagine that two firms sell identical or very similar products. Both firms choose sales and price adjusts to clear the market. This is a classic Cournot duopoly. In Figure 1 the conventional Cournot equilibrium is depicted given the two reaction curves of the firms. Let $\pi_1$and π_2 denote the profits of the two firms, 1 denoting the home country-located but foreign-owned firm and 2 the foreign country-owned and -located firm. Both firms sell into a third country we shall refer to as Rest-of-World (ROW). What is the objective of the home government? The conventional efficiency argument is that in the absence of a home consumer interest, home producer surplus would be the appropriate objective of the home government. In this case, however, there is no home producer surplus nor are economic profits accruing to home citizens, since the firm which is the recipient of the oligopoly rents is owned by foreigners and the home government has no interest in subsidizing or taxing exports. Hence, *in the event that the home exporter is 100 percent foreign-owned and the home government is concerned only with domestic efficiency* *objectives, it has no interest in intervening in the export market on behalf of the foreign-owned firm.*

It is worth noting that if the foreign-owned firm is a multinational whose source country is "foreign", then the industry's oligopoly rents are accruing entirely to foreign. In this case, a strategic trade policy on the part of foreign would be to foster collusion among its two exporting duopolists. Given the absence of a consumer interest in home, it would have no objection to this cartelization on domestic efficiency grounds.

Governments often pursue objectives other than pure efficiency and this is certainly the case in policies directed toward FDI. Two alternatives which are often suggested are: i) employment objectives and ii) improvements in the balance of payments. The strategic trade policy literature has not been directed at policies motivated by either of these considerations, but given their importance in the policy debate on FDI and trade, it is useful to see where they lead.[10]

Suppose that the objective of the home government is to maximize employment in the export industry controlled by the foreign firm that is subject to a government expenditure constraint. This objective could arise either because the economy is characterized by sector-specific structural unemployment, which is impervious to macroeconomic correction, or because of perceived spillover benefits to the economy through general training effects which are available only by generating employment in this industry. Alternatively, wages in the industry in question may contain economic rents. In the latter case the objective of increasing employment within the industry could be justified on national efficiency grounds.[11] Ignoring factor substitution issues, the employment objective of the home government is promoted through increases in the output of the foreign firm in the export market. This can be achieved in a number of ways, but most involve either a sales or production subsidy to the home firm — i.e. export subsidies. The incentive to subsidize would be balanced against the social cost of the additional revenue required, which is raised through distortionary taxation.[12]

Given an employment objective, the case for an export subsidy policy is more general than in the conventional Brander-Spencer model. As noted below for that model, the case for subsidy hinges upon an industry conduct described by Cournot quantity competition. In the model with home employment as the objective of the home government, the result that exports should be subsidized is independent of the nature of the game being played by the two competing firms;[13] the objective of the home government is to raise output produced in the home country, not to increase the profits of the firm producing in its jurisdiction. In the instance in which the duopolists are Bertrand price competitors, the export subsidy is a particularly effective tool for raising output in the absence of retaliation by the foreign government. If both home and foreign governments attempt to engage in job shifting, the equilibrium will involve large subsidies to ROW consumers and little benefit to either country in terms of net jobs shifted between countries, although the world industry as a whole would be larger than it would otherwise be, meaning greater employment within that industry.

To what extent does the employment argument made for an activist trade policy hinge upon who owns the firm? In fact, it does not matter. National firms and foreign-owned firms should be treated alike. If governments wish both to shift jobs as well as rents, the problem becomes more complicated and, indeed, the two objectives may conflict if the exporting firm is a national firm. This is the case, for example, if the home and foreign firms are Bertrand duopolists. Export subsidies increase output but lower net rents shifted, while export taxes raise the rents shifted but lower output. *The general implication of this analysis, therefore, is that foreign ownership of an export firm eliminates the rent-shifting motive for policy, therefore simplifying the design of trade policy in export industries.*

For a number of reasons, trade or industrial policy might be directed toward balance of payments considerations. A sector-specific trade deficit might be of concern for the reasons of externality cited previously, but this case has implications similar to the employment objective. If exchange rates are fixed, as they are in many small developing countries, or exchange rates are misaligned, as may be the case with floating exchange rates, trade policy might be used as a second-best tool to deal with balance of payments disequilibrium or foreign exchange requirements. Suppose the objective of policy is to maximize net foreign exchange earnings in an export sector occupied by one firm. Maximizing export earnings is equivalent to a revenue maximization objective. The government would therefore want to set output levels so that the absolute elasticity of export demand was equal to one at the resulting equilibrium. It is well known that oligopolists will operate only where their own demand elasticities exceed unity; therefore, the home government would generally need to subsidize production in order to maximize export revenues.[14]

If the firm is foreign-owned, however, the problem is complicated by the fact that those foreign exchange earnings which do not accrue to the home country are of no value in meeting the home country's objectives. Unless the foreign-owned firm reinvests those earnings in the home country, the only export earnings that accrue to home are payments by the firm to its home-located factors of production. Subsidizing export sales while increasing the value of export revenues may simply result in larger profits accruing to the foreign-owned firm. To increase net foreign exchange earnings accruing to the home country it may well be optimal, instead, to tax the foreign firm. (This is really a variant on the old MacDougall argument on the optimal taxation of foreign income[15] applied to the product market instead of the factor market.)

There appears to be no general case for conducting a strategic trade policy in export industries when the principle exporting firms are foreign-owned. If rent-shifting is the objective of policy, then foreign ownership of the industry eliminates the need for a strategic trade policy. If, on the other hand, the objective is employment in an imperfectly competitive export sector, strategic subsidization of exports may be necessary. It is interesting that in this case the policy should be non-discriminatory with respect to ownership patterns — so both foreign and domestic firms alike would be subsidized.

FOREIGN OWNERSHIP AND DOMESTIC MARKETS

IN THIS CASE DOMESTIC CONSUMER INTERESTS are central to the question of policy design. Much of the older literature on FDI focussed on the impact of import tariffs on FDI and the possible efficiency consequences. This question is treated in section five. For the moment, it is assumed that foreign ownership of a domestically producing firm is taken as given. The home market in question is assumed to be non-tradeable or, alternatively, a prohibitive import tariff eliminates trade as a relevant consideration. We first consider the case in which the foreign firm is a home market monopolist, then we examine the implications of competition in the home market.

The home country is better off having a product supplied by a monopolist than not having the market served at all. However, appropriate taxation or subsidization of the monopolist is by definition superior to a laissez-faire policy. It is worth recalling that in the case of a domestically owned monopolist, the basic resource misallocation is that too few resources are allocated to the monopolistic sector. Policy should therefore be directed at pushing resources into the monopolistic sector. Subsidizing production is one method to achieve this. On grounds of world efficiency, this is still the case if the monopolist is foreign-owned. On national grounds, however, the profits that accrue to the foreign firm are of no national benefit. The optimal policy may be to tax the monopolist, that is, by pushing resources out of the monopolized sector but shifting rents from the monopolist toward the home treasury. Under what circumstances, if any, might this be the case?

Let q denote output in this sector and $S(q)$ a gross surplus function, defined as the area under the inverse demand curve in the usual textbook picture. Market price is given by $p=S'(q)$; net domestic consumer surplus is given by $C= S(q)-pq$. If the government imposes a per unit tax of t on the monopolist, home welfare is given by

$$W(q) = C(q)+tq \tag{1}$$

It is straightforward to show that at $t=0$ we have

$$dW/dt = q(1-dp/dt) \tag{2}$$

The monopolist with marginal costs c and a tax rate of t sets marginal revenue equal to $c+t$. If a tax of $1 on the monopolist raises price by less than $1, then the result is improved home welfare. The loss in consumer surplus due to a price increase is more than offset by the monopoly rents shifted away from the foreign monopolist to the home treasury. The circumstances in which this type of policy is feasible are really quite plausible; a sufficient condition is that the marginal revenue curve rise at a rate faster than the demand curve (the linear demand curve being the classic example).[16]

Applying national efficiency criteria this appears to be yet another case for taxing foreign capital, although in this example it is quite clearly FDI capital with monopoly power in the home product market. Note, however, if the policy objective function is employment or output, the opposite conclusion holds. As in the case of a domestically owned monopolist the aim is to encourage output and this requires a subsidy; in the case of employment objectives, non-discriminatory treatment for foreign-owned firms is called for.

Now consider the case in which both a foreign-owned and domestic firm compete in the home market. The competition is assumed to be oligopolistic so there is a resource misallocation due to oligopoly as well as economic profits accruing to both the foreign and domestic firms.

On grounds of national efficiency the home government will be concerned about both domestic consumer interests and the profits of home-owned producers. The presence of foreign-owned producers is beneficial to the extent that they either a) improve competition in the home market through lower price-cost margins), b) provide superior price-quality package to the home firm product, or c) supply at lower cost than domestically owned producers. Achieving an optimal policy based on national efficiency objectives calls for a balancing of these potential gains against potential losses in the form of transfers of monopoly rent abroad.

To keep the analysis simple, assume that the products of the foreign and domestic firm are close to perfect substitutes. The foreign-owned firm offers no particular advantage, therefore, in terms of product variety or quality to the home country.[17] First, suppose that both firms supply the product at the same cost. Policy should provide for rent shifting toward the home firm and lower prices to benefit consumers. A discriminatory policy is clearly optimal in this instance: subsidize the home firm and tax the foreign firm. Indeed, it can be shown that if both firms supply with constant or declining marginal cost, the foreign firm should be taxed out of existence with all oligopoly rents shifted to a domestic monopolist. If discriminatory policy is not feasible, the presence of the oligopoly rents accruing to the foreign-owned firm reduces the incentive to subsidize production and may imply that a tax on the industry is appropriate.

If a foreign-owned firm has lower costs than a competing domestic firm, the reason may be that it is a multinational subsidiary and enjoys the cost advantages which accrue from the public good nature of headquarter services supplied by the MNE. On the other hand, a foreign-owned firm might have proprietary access to a process innovation which is the reason for the presence of the subsidiary in the industry. In any case, the presence of FDI can be thought of as a substitute for the trade which might otherwise occur, and comparative advantage confers a cost advantage on the foreign-owned firm. In these circumstances efficiency-oriented policy objectives must carefully weigh the consequences of displacing low-cost foreign production with higher cost domestic-sourced production. Given a sufficient cost difference, it does not make sense to attempt to rent shift toward either the domestic-owned firm or the home treasury. Indeed, it is possible that the optimal policy will discriminate **against** the domestic firm, thereby forcing a greater share of total industry output to be produced by the more efficient foreign firm.

If industry employment is the policy objective, then the ownership of firms within the industry is really a matter of indifference to policy makers. Employment in a foreign-owned firm is a perfect substitute for employment in the domestic-owned firm. Employment can be stimulated by a variety of policies, none of which is particularly motivated by imperfect competition in the product market. However, to the extent that there are entry barriers (and hence economic profits) in the industry, subsidies to foreign firms which result in increased foreign profitability must be weighted at lower social value than a similar subsidy to a domestically owned firm.

IMPORTS AND FDI IN IMPORT COMPETING INDUSTRIES

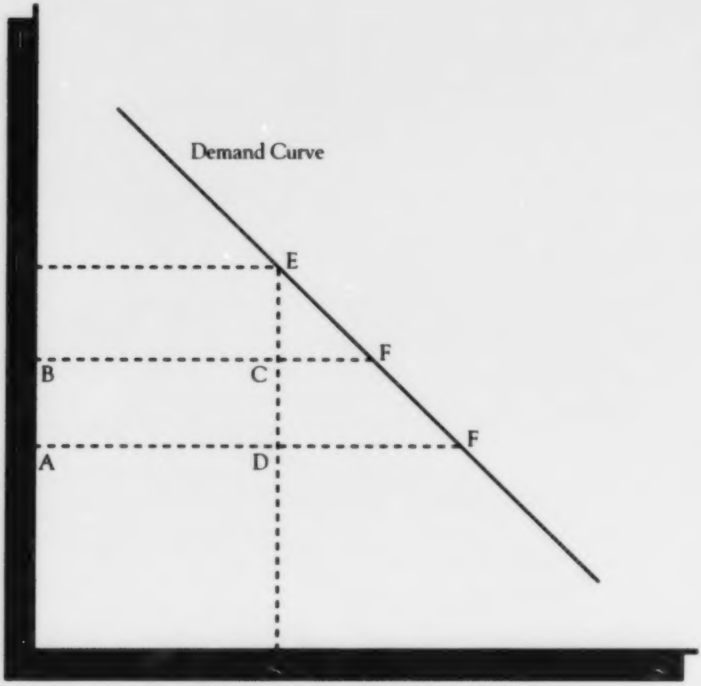
WHEN ENTRY BARRIERS EXIST such that home and foreign goods or technologies are imperfect substitutes, exporting from the source country is an alternative to FDI for the foreign firm with proprietary access to a product brand or particular technology. A classic issue in the debate on the costs and benefits of FDI centres on how policy affects the decisions firms make between FDI and export, and the efficiency consequence for the host country of the FDI flows that may result from such a policy. In the ongoing discussions of the impact of the tariff on the Canadian economy it is often argued that the inflow of FDI that accompanied the rise in the Canadian tariffs in the 1930s was caused by the tariff and imposed real income losses beyond the usual static welfare costs of the tariff.[18] This argument is plausible if there are firm-specific advantages which make FDI an attractive alternative to exporting over the tariff wall or to arm's-length licensing arrangements with domestic producers.

With the signing of the Canada-U.S. Free Trade Agreement (FTA), the debate on FDI and import protection of the home market has shifted to an argument about the possible effects of foreign takeovers of Canadian-owned firms with the reduction in tariff and non-tariff barriers. Such takeovers accompany rationalization in an industry which occurs as a consequence of reduced trade barriers[19] and which may also take the form of horizontal mergers in an attempt to achieve economies of scale. Should Canadian merger policy be concerned with the foreign ownership issue in these cases?

The traditional analysis of mergers was undertaken by Williamson (1968) who identified the tradeoff between efficiency gains due to mergers, and monopoly pricing resource losses due to greater market power exercised as a consequence of a merger. It is clear the Williamson trade-off is substantially modified when the target company is domestic and the acquirer is foreign. The analysis is depicted in Figure 2.

FIGURE 2

FOREIGN TAKEOVER WITH EFFICIENCY GAINS AND MARKET POWER POST-MERGER



The conventional tradeoff identifies the cost-saving rectangle ABCD against the monopoly welfare loss DEF post-merger. Merger is assumed to lower unit costs from c to c*.

In the case of foreign ownership of the post-merger monopoly, the Williamson trade-off is not relevant to the home government. If enhanced market power raises prices and thus monopoly rents, *all cost savings are captured by the foreign-owned monopolist* and domestic consumers are actually worse off because of higher post-merger prices. In such circumstances, foreign takeovers should be prevented and domestic takeovers should also be subject to the usual cost-benefit analysis.

This simple analysis must be carefully qualified, however, by the extent of entry barriers in the industry. If entry barriers are low, such that entry is feasible over the long run, then cost gains will ultimately be incorporated in lower consumer prices. The argument then shifts to whether discouraging or accommodating potential foreign entrants will impede or assist the adjustment process toward a competitive rationalized industry. But this also begs the question of whether import competition alone is sufficient to discipline the domestic industry through competition. In the absence of long-run entry barriers which yield long-run monopoly rents, there is no obvious reason why the government should discourage foreign entrants, either by direct prohibition or by raising the cost of entry through screening tests and other bureaucratic delaying mechanisms.

For a wide variety of reasons, there are significant differences across firms in absolute efficiency over the short- and medium-term. If rationalization is to have positive effects on the economy, low-cost firms should take over high-cost firms in an efficiently functioning takeover market. In some industries the low-cost firm is bound to be the foreign-owned firm and clearly the takeover should be allowed. If the low-cost firm is domestic, then it may not be the successful acquirer for some other reason — possibly a capital market imperfection that shifts the advantage to foreign-owned acquisitors. There may well be something to the imperfect capital markets argument, but clearly the solution is not to prohibit FDI but to encourage policies under which domestic capital markets function efficiently and on terms competitive with other countries. The "cost of capital" argument of Graham and Krugman (1989) is clearly relevant here.

Temporary increases in the cost of capital to domestic firms during a period of transition, such as that accompanying the phase-in of the FTA, could have permanent effects on the structure of Canadian industry by giving foreign firms a temporary entry advantage which subsequently becomes embedded in higher market shares and firm- and industry-specific sunk costs. Such barriers to exit become barriers to entry on the part of domestic firms and may lead to a much longer period of adjustment to reduced trade barriers between Canada and the United States. These "hysteresis effects" in the transition imply that firms from countries with low interest rates (cost of capital) and preferential access to their home capital market are temporarily advantaged in the market for the acquisition of assets vis-a-vis firms from countries with high interest rates. Attempting to restrict FDI entry or horizontal merger in such circumstances would be only third best. Second best would be to subsidize domestic takeovers by creating a level playing field in the acquisitions market.

FDI AND MODERN PROTECTIONISM

IN THE CURRENT STATE OF INTERNATIONAL TRADE RELATIONS, the industrial countries are a long way from practising universal free trade. A substantial volume of international trade is "managed" by international bilateral agreement. The VERs against Japanese auto imports and the quotas in textiles under the MFA are two prominent examples. Managed trade tends to be quantity regulated and it is well documented that the importing countries using these protectionist policies pay a high price in terms of foregone economic welfare. It is ironic that a good deal of FDI has been encouraged by the presence of managed trade agreements; an example is the decision of Japanese auto producers to invest in American and Canadian plants. Much of the Canadian-hosted investment can be attributed to the FTA — on the grounds that foreign producers can avoid harassment in the American market by producing within Canada. Arguing by analogy to tariff protection it might therefore be suggested that given the existence of managed trade as the politically-negotiated outcome in the trade policy arena, it would be a second best policy to restrict foreign investment. As in the conventional argument,[20] the inefficient import-competing sector is artificially expanded by protection; investment inflows merely expand this sector inflicting further losses on the economy.

The above argument on the costs of FDI in the presence of protection depends on two assumptions: 1) perfect competition in all product markets and, 2) the use of tariffs as the means to protect the home market. Relaxing either of these assumptions will change the second-best optimality of limiting foreign investment. Assume a monopolist is initially importing into Canada under a quota, all quota rents accrue to the monopolist supplier. Now suppose the monopolist decides to shift production to Canada via FDI and produces the desired quantity subsequent to re-location, then, if the quota was initially binding, output would expand and prices would fall. Both the monopolist and domestic consumers would be better off. Now assume the supply side is characterized by some oligopolistic competition with import competing home supply. Foreign competitors who are quantity constrained under managed trade are effectively precluded from price competing in the home market. Following the analysis of Harris (1985) and Krishna (1989), the quotas serve as "facilitating devices", raising prices in the industry relative to what equivalent tariff protection would accomplish. The decision by a foreign firm constrained by import quotas to undertake FDI would remove the facilitating device and encourage competition in the domestic market.[21] Price-cost markups would fall and quota rents would be transferred from foreign suppliers to home consumers. In these circumstances FDI is essentially a direct mechanism for increasing competitiveness of the domestic industry, given the distorted nature of trade policy.

A different line of argument is relevant in the case of managed trade in competitive industries. For example, suppose textiles is competitive in the sense that entry is cost-less, except for administrative interference. The rents from existing textile quotas accrue to foreign producers holding the quotas. A decision by a potential foreign entrant to enter the home market and produce via FDI would increase the domestic supply of low-cost textiles. Given a binding quota, foreign imports would be unchanged. The lower-cost additional domestic supply would reduce domestic prices and thus transfer quota rents to domestic consumers. The simple logic underlying the redistributive nature of quotas which are held by producers, means that any mechanism of increasing lower-cost domestic supply is clearly home welfare improving. If the supply can be increased by FDI then it would be home welfare improving.

From these examples, restricting FDI appears to be a "shoot yourself in the foot" policy — given the nature of managed trade quantitative restrictions. If quantitative restrictions on trade are permanent, restricting FDI serves no useful purpose; it merely contributes to further efficiency losses already imposed on the country applying the trade restrictions.

THE EXTERNAL COST/BENEFIT CALCULUS OF FDI

THE CANADIAN POLICY DEBATE on FDI is confusing. One side argues that when multinationals use FDI to set up Canadian subsidiaries, the country gains an important source of technology transfer, while the other side argues that foreign takeovers of former "Canadian" high-technology companies have a negative effect on the Canadian capacity to innovate.[22]

The distinction between these cases is rooted in the structural characteristics of the market for the development, transfer and sale of new technologies and products. The inward FDI associated with foreign subsidiaries of MNEs is principally associated with the technology transfer aspect of the process — that is, firms set up in Canada to produce, distribute and market a product or technology that has been developed by the firm elsewhere in the world. The Canadian subsidiary may undertake development in the sense that the product is changed to suit the Canadian market, but the fundamental innovation, nonetheless, was developed elsewhere in the firms' global operations.

Concern with foreign ownership of Canadian high-technology firms is more closely connected to the original research stage of technological development and transfer. The issue here is not the inward flow of technology but rather the outward flow of technology and what are perceived to be significant national spillovers associated with this activity. While multinational firms may be seen by technology importers as efficient vehicles by which technology is transferred internationally, they can also be seen in a quite different light by technology exporters. This is not a new debate in economics.

Beginning with the product cycle model of Vernon (1966), much of the literature on North-South trade has been concerned with the asymmetry between technology exporters and technology importers. There is now a substantial theoretical literature which demonstrates that technology exporters (North) suffer real income losses from policy or institutional mechanisms which speed up technology transfer; this is true even though the technology importers and world efficiency as a whole improve by such mechanisms.[23] Similar to the situation in the United States and Japan, Canadian policy makers are caught between these two opposing views of the multinational firm in the technology transfer process.

At the heart of this argument is the notion that there are external costs and benefits associated with research, development and trade. As noted in the introduction, Canada has a long history of policy-related debate on the costs of sovereignty versus the benefits of technology transfer brought by foreign direct investment. For the most part, economists have supported the notion that the benefits of technology transfer via FDI are large for a small technology-importing country such as Canada.[24] Furthermore, implicit in the notion is that accompanying these transfers are "external economies" or spillovers for which no direct compensation is made. Canada is thus considered to be a large net beneficiary from these spillovers. The literature has always been weak on the precise nature of the spillovers, but geographic proximity to the use or production of new technology is usually thought to be important in the process. FDI is also thought to facilitate spillovers because workers learn how to make and use new technologies and this knowledge is transportable at low social cost to other workers and firms. As such knowledge diffuses through the economy its benefits are widely felt.

Clearly, if FDI is an important mechanism by which significant social benefits of foreign origin, including both technological and institutional knowledge and innovations are transferred, then it is quite possible that the same mechanism (FDI) is capable of facilitating international transfers of some "bad" or "dubious goods". It is this type of resistance to foreign ideas that has made countries like Japan much less receptive hosts of FDI than Western economies consider normal. In Canada, given the quantitative importance of American FDI within Canada, it is American influence which is the usual source of concern.

The arguments about the external effects of FDI have recently appeared in a quite different guise with the takeover of a Canadian medical research enterprise, Connaught Labs, by a French-controlled conglomerate. In this case concern about the foreign takeover is more closely tied to the perspective of a technology-exporting country rather than that of a technology importer. There are two parts to this concern. First, as a technology exporter, the Canadian firm should be capable of earning innovation rents which contribute to Canadian real income via product cycle type arguments. If such rents accrue to foreign equity holders, this begs the question has Canada "lost" something by giving up its ownership claims to an innovation source? Second, high-technology firms generate substantial external economies on the national and local economies through a variety of mechanisms; these include spillovers to workers in the form of general training, facilitating networking economies among related specialists, and the development of supplier markets which are available to other related firms. However, multinational firms tend to exhibit a "headquarters" bias in the location of R&D activities. Thus, a foreign takeover of a Canadian R&D-intensive firm can result in the re-location of that activity elsewhere, with the associated loss of spillovers and a significant negative effect on the economy.

These arguments about innovating firms and foreign ownership are now being aired in the United States, largely because of concern over Japanese direct investment.[25] In Canada, however, the recent arguments are somewhat different, motivated to some extent by the large country/small country asymmetry.

INNOVATION RENTS AND FOREIGN OWNERSHIP

R&D IS AN INVESTMENT PROCESS under uncertainty which leads *ex post* to innovation rents, *if the innovation is successful*. If unsuccessful, the firm fails to re-coup its sunk costs in R&D. In a competitive innovation market the expected *ex post* innovation rents must equal the *ex ante* investment cost; this is brought about by sufficient entry at the innovation stage of the industry as to reduce either the chances of winning the R&D competition or the extent of post-innovation monopoly profits. The extent of innovation rents is determined by the degree of appropriability in the post-innovation market.

Economists have long disagreed as to the extent of this appropriability.[26] In a pure public good world, Arrow (1962) argues that imitation is without cost and instantaneous, thereby eliminating all rents and eliminating the *ex ante* incentive to invest in the production of knowledge. Alternatively, if all returns from innovations are privately appropriable, then we are closer to a post-innovation pure monopoly world, as in Schumpeter's description of capitalism. However, *ex post* monopoly can be matched by *ex ante* competition via entry at the innovation stage of the industry leading over the long run to average rates of return in the industry on R&D. Significant entry barriers in R&D-intensive industries can also lead to either above normal private rates of return or true monopoly profits to the successful innovators. These are long-run rents that are not eliminated, given the presence of entry barriers to the industry. Innovation tends to be undertaken by the successful firms, with attempts at innovation by outsiders thwarted by large entry barriers. The real world contains a number of industries, some of which resemble the competitive innovation market structure, and others which are more like the pure monopoly case. The North-South trade literature is predicated on the assumption that imitation proceeds slowly but inevitably. There are consequent spillovers in the after market, but the lags in technology transfer between countries create international real income differences between the innovating North and the imitating South. Although initially applied to trade between a developed industrialized North and an undeveloped semi-industrialized South, these models now have much wider application and depend on less dramatic differences between trading regions. To date, they offer the most coherent explanation available as to the source of international productivity and factor price differences.

Real income differences emerge from two different sources, but both hinge on the underlying assumption that it is the North that innovates first. First, income is higher in the North because it has higher absolute productivity as a result of using better and newer technology. This is a simple consequence of the nature of general equilibrium in a world with differences in absolute productivity levels — it does not depend on the presence or absence of long-run innovation rents. In an advanced innovating country, therefore, all private innovating firms can earn *ex ante* rates of return on R&D that are competitive, but the country as a whole will have higher real incomes than the South in the form of higher wages and returns to other specific factors.

The second potential source of real income differences emerges from long-run monopoly rents as assumed in the models discussed earlier. The monopoly rents are a consequence of entry barriers in the product markets, possibly due to the economies of scale associated with R&D. While the world as a whole suffers monopoly pricing losses, the profits of the innovating monopolist accrue as real income to the North. Note that in both cases, the real income differences persist because of imperfections in the pace at which technology is transferred.[27]

Where does the debate on foreign ownership fit? It begins with the assumption that national innovation leads to higher real incomes via one or both of the routes outlined above. If the firm in question is foreign-owned, then rents that accrue to capital owners will be a cause for concern — as would the foreign ownership of any monopoly rents.[28] If all rents accrue to other factors, however — particularly wages — then the question of ownership should be irrelevant. In a world of mobile capital among developed countries, assuming a competitive *ex ante* R&D market, it is unlikely that persistent income differences across countries can be explained by the real return to capital. Evidence of persistent differences in the form of returns to the specific factors[29] would be needed. The ownership identity of firms would be of no particular national concern; the concern would be that the country as a whole have a reasonable share of innovating industries — that is, that it be in the innovating North and not the imitating South. Many other policies might affect where a country appears in this spectrum, but policies directed at ownership *per se* would seem to have little to do with it.

There is a presumption in the foregoing argument that innovation in a particular location implies that production, or at least the high value-added component of production, occurs in the same location. The application of domestic factors of production to superior technology leads to higher incomes. In a small country like Canada, there is often concern that the linkage of innovation and production is weakened by foreign ownership. Multinational firms can use a technology developed in one country in any other country that is technologically able to assimilate it quickly — in other words, the transfer lag is reduced to virtually zero. Even though the transfer lag is reduced, it is possible that imitation by competitors is still slow and costly. Thus, firms can transfer technology internationally very efficiently, but private appropriability over the short haul is still substantial. It is this conjunction of assumptions that is most problematic for economies like Canada's. In these instances the location decision a foreign-owned MNE makes to develop a technology is completely separate from the decision it makes concerning its production location. Canada must therefore compete separately as a location for both innovation and production. If this is an accurate description of the world, labour in a given skill category everywhere competes. Wages of a particular skill category must therefore clear the world labour market, not just a national labour market, with the result that production wages to lower skilled workers in the advanced industrialized countries decline. In the language of trade theory, unskilled production labour becomes the abundant factor in all countries and skilled R&D labour becomes the internationally scarce factor. Wage differences between nations are replaced by increased wage differentials between skill categories within nations.[30]

We are still a long way from achieving the level of international economic integration assumed above. However, multinationals have, to some extent, broken the innovation-production link. To the extent that foreign takeovers of Canadian innovation-intensive firms further weakens this link, it is possibly to the detriment of labour involved in the new technology. A foreign firm might decide to develop and produce a "Canadian" product in the United States or Europe with the result that wages to workers who might have been employed in that activity are lower than they would otherwise be. In the short term, therefore, labour groups could charge that foreign takeovers of Canadian high-technology firms mean "exporting jobs", just as American multinationals were accused in the 1960s and 1970s. However, a Canadian-owned firm has exactly the same incentive as a foreign firm to undertake production offshore. The root problem, then, is not one of foreign investment but rather the globalization of production.

There are two reasons to be extremely wary of carrying this argument too far. First, at the level of the firm, there are still significant links between innovation and production, for higher-technology products, particularly at the more skilled levels. Thus the objective of policy should be to encourage innovation both to provide high-wage jobs in the innovation-intensive firms, and as a means to higher production wages; restrictions on foreign ownership are not likely to help in this regard. Second, Canadians want the best possible price for Canadian-developed technology. Large foreign multinationals are an obvious market, but by restricting their ability to buy Canadian assets we effectively forego as a nation the ability to benefit from their firm-specific assets. Accordingly, the Canadian innovator may sell the technology abroad in an arm's-length transaction on much less favourable terms than could be secured through development of the same technology by a foreign multinational. Finally, as the source country for a number of multinationals, even a small country like Canada has a significant interest in seeing that its own firms are allowed access to the markets for new technology in other countries. Clearly, discriminatory treatment of foreign multinationals within Canada could lead to similar treatment by other countries against Canadian firms.

R&D SPILLOVERS

ONE OF THE MAJOR CONCERNS of many who comment on foreign takeovers of Canadian high-technology firms is the spillover to the local and national economy from commercial research and development activity. These spillovers are of a wide variety and concern that Canada might not be benefiting from such spillovers is motivated by the success of such technologically-intensive areas as Silicon Valley and Route 128 in the United States.[31] A number of empirical studies — ranging from those on the U.S. textile industry in the 19th century to the computer industry in the last two decades — suggest that general spillovers accompany the development of new technology and industries. However, it is difficult to obtain even general estimates of the magnitude of such spillovers.[32] The worry over the foreign takeovers of domestic firms intensively engaged in research and development derives from the belief that large-scale multinationals tend to centralize R&D activities in the source country or in large markets. This is known as the "headquarters effect".

The most plausible explanation for a locational concentration bias in R&D is economy of scale. The notion that R&D should be located near a firm's headquarters is logically related to economies of scope between other management activities and R&D. The evidence for centralization is stronger than the evidence for a headquarters effect. For countries the size of Canada, the evidence[33] certainly suggests that foreign-owned multinationals tend to do less R&D in Canada than do similar domestic-owned firms.

As a result of this centralization effect, it is argued that foreign takeover of Canadian R&D firms will result in the re-location of the R&D activity to a larger market, or a significant technical downgrading in the nature of the activity. This would reduce the external benefits to the home country. There is not much formal theory to draw upon in addressing this question. While there is a fairly large literature on externalities, unfortunately little of it deals with the kind of locationally mobile external benefits of concern here. Finally, for the centralization hypothesis to be of practical concern, the quantitative importance of both the external effects and the internal economies of scale in R&D must be established.

Accepting both external spillovers and economies of scale in R&D, it is still not clear that there is a problem on theoretical grounds. In terms of partial equilibrium analysis, a particular multinational might well choose to centralize its R&D activities, but in terms of general equilibrium analysis, not all firms will choose to do so. Economies of scale in R&D at the firm level are not large relative to the size of the Canadian economy. In multi-industry general equilibrium (GE) theory, economies of scale are typically expected to result in more specialization than in a constant returns framework. The general equilibrium argument also applies to R&D; a few large R&D establishments would be expected rather than many operating at a scale in proportion to the size of the country. The external benefits from R&D would still exist, although it might be expected that with less diversification some of the forms of the spillover might be different.

There is a logical possibility in economic models with increasing returns to scale that cannot be ruled out on theoretical grounds although its practical importance is impossible to assess. It has long been known by international trade economists that, given an industry exhibits external economies of scale (as would be the case under the positive spillovers hypothesis) at the level of general equilibrium in the world economy, there is a distinct possibility, although not necessity, of multiple equilibrium.[34] In an otherwise symmetric world, the presence of one industry with external economies can lead to multiple asymmetric equilibrium with one country having a much greater share of the industry exhibiting external scale economies in one of the equilibria than in the other. Since the country with a high share of the scale-intensive industry would have lower costs than the other country, it would normally be relatively better off. In such circumstances, there is a good case for subsidizing the industry exhibiting external economies for the usual Pigovian reasons. However, if one country subsidizes and the other does not, there is a possibility of switching from one equilibria to another, with large changes in the allocation of activity and distribution of economic welfare. When appended to an appropriate dynamic theory, this suggests that history matters and policy matters in very important ways. The first country to get a foothold in an industry subject to internal increasing returns might obtain a permanent cost advantage in that industry.[35] How would the presence of foreign ownership in the increasing returns industry affect the analysis? Probably not very much, in the absence of a centralizing force such as internal R&D scale economies. But if the centralization hypothesis were correct, then foreign takeovers and a consequent re-location of the external economy-generating activity could clearly lead to a switch from one equilibria to another, with negative consequences for the country losing the external economy-generating activity — that is, R&D. While these ideas should not be dismissed as irrelevant, the policy relevance of these multiple equilibrium models is still unresolved, and possibly unresolvable.

There are also other policy implications that follow from a more basic economic analysis of this problem, again taking as givens both the presence of external economies and the centralization tendency of R&D.

First, the presence of locationally-mobile external effects can give rise to polices that attempt to shift these externalities strategically. If the sunk cost component of R&D is high, some countries will seek to pre-empt others by moving first in the R&D game. This could conceivably make both countries worse off. However, if the principal benefits of R&D are the external benefits that accrue to nations rather than the firms undertaking the R&D, then the competitive subsidization of R&D by both countries may well improve both *national* and *world* welfare. Because firms undertake to do too little R&D relative to the social optimum, the subsidization of R&D clearly improves the situation relative to no intervention. However, it is also possible that a non-cooperative policy equilibrium will involve *too much subsidy relative to an efficient outcome* from a world standpoint. Thus, competition between governments may result in overcorrecting a basic market failure — because at the national level the incentive is both to correct an internal market failure and to pre-empt the other country.

Second, different firms have differing capacities to conduct R&D and its associated activities. This becomes a problem when a foreign firm is clearly the best qualified to carry out a particular type of R&D, and it has a strong reason, therefore, for re-location of the activity outside the home country. Attempts to keep the R&D "at home" by restricting the foreign takeover may mean that the R&D undertaken has a higher cost under domestic ownership. The potential benefits of the positive spillovers must be weighed against this cost. That is, preventing a foreign takeover or imposing foreign investment performance requirements involves a tradeoff of these two effects even in the absence of strategic interaction with other governments.

Third, restrictions on foreign takeovers of high-technology firms would very likely reduce the average acquisition price for firms in such takeovers. In this connection, a foreign MNE might well have access to firm-specific advantages in foreign distribution and marketing which would make the home innovation worth more to the MNE than to any domestic firm that qualifies as a potential acquirer. By reducing average acquisition prices, incentives for venture capitalists to invest in Canadian R&D start-ups would be reduced, and the total capital available for new R&D ventures would therefore decrease. In the absence of foreign takeover restrictions, a certain amount of leakage of successful R&D firms abroad might be expected, along with the accompanying external effects. Restricting foreign investment by reducing the flow of capital to new start-ups would reduce the total investment in R&D but increase the percentage of that investment that stays at home. An appropriate policy response to the reduced aggregate investment in R&D start-ups, therefore, would be to subsidize domestic takeovers through favourable tax treatment or loan subsidies, thus raising the average acquisition price and improving the *ex ante* incentives for investment.

CONCLUSION

THIS PAPER HAS CONSIDERED TWO ASPECTS of the issue of foreign direct investment in Canada: 1) the strategic trade policy implications of foreign direct investment with trade policy reasons argued in support of controlling foreign direct investment and 2) the complex issues surrounding foreign takeovers of technologically-intensive Canadian-controlled firms. Both sets of issues were reviewed in light of the literature on strategic trade policy developed over the past decade.

The overall conclusion of the paper is that strategic trade policy offers little reason to justify control of foreign direct investment. To the extent that there is any other conclusion, it is simply that FDI in a domestic industry probably mitigates national incentives to engage in strategic trade policy. The only exception to the irrelevance of foreign ownership is the case of a horizontal merger involving a foreign acquisition in circumstances in which post-merger monopoly power is enhanced. Even if such a merger improves technical efficiency, it is detrimental from the national point of view because it involves transfer of rents abroad.

In the context of high-technology industries, the spillovers argument is a powerful one, although it is difficult to unravel its precise logic. Coupled with the centralization argument, it has had a strong influence on the view some have taken toward R&D — or the lack thereof — in foreign-controlled firms. This paper suggests that, potentially, the key problem for a small country like Canada is with the centralization of R&D by large firms. Restricting foreign takeovers, or imposing significant performance requirements on foreign direct investment, is unlikely to correct the "small country" problem. Indeed, Canada is — and will no doubt continue to be — a large net beneficiary from inward FDI flows. If R&D is a scale-intensive activity, as well as intensive in the use of capital and skilled labour, the best policies are those that strike at the root of the problem: 1) keeping foreign markets open, thus mitigating the scale bias against small countries; 2) ensuring that Canadian firms and entrepreneurs have access to capital on internationally competitive terms through low real interest rates and efficient capital markets; and 3) ensuring that Canada has both a labour force compatible with the high-skill requirements of technologically progressive industries and labour market practices consistent with the nature of the industry. Sound policies in these areas is far more important than any attempt to control foreign investment which has fairly obvious costs and dubious economic benefit.

ENDNOTES

1. Surveys of the literature on MNEs include Caves (1982) and Cantwell (1989). Strategic trade theory is reviewed by Harris (1989) and Helpman and Krugman (1989).
2. Ed Safarian (1969) has written the classic source on Canadian policy toward FDI; Steve Globerman (1985) summarizes much of the more recent Canadian policy literature.
3. This debate is reviewed by Caves (1982) and Kindleberger (1968).
4. Harris (1989a) reviews the evidence for and against the factor endowments approach to explaining trade flows.
5. Resource trade continues to be well explained by factor endowment theory and is the least controversial aspect of the modern debate on trade flows.
6. These are reviewed in more detail in Harris (1989b).
7. Economists who think of policy games as symmetrical Prisoners' Dilemmas find this argument counter intuitive. It has long been known in the discussion of tariff wars that one country can be better off in the tariff-ridden equilibrium than in free trade equilibrium. In Harris (1989b) I discuss some of the reasons the prisoner's dilemma characterization of policy games may be incorrect. An example would be one in which country A has a fairly elastic supply of resources to its "strategic" industry while the competing country, B, has an inelastic supply of resources to the same industry. A "threat" of subsidy in country A would carry with it much larger output consequences in the "elastic" country than in the "inelastic" country. It is conceivable in this case that the country endowed with the

potent threat capacity would choose to carry it out, knowing that retaliation by country B would be inconsequential.

8. See Porter (1990) for example.
9. There is a body of policy literature and academic literature that argues this is not the case. For example, a foreign manager may pursue a goal in a monopolized market to the detriment of a host country. The recent debate on the efficiency of the takeover market has raised considerable doubt as to the validity of the profit maximization goal. For the moment, the debate is inconclusive. See Symposium on Takeovers, Journal of Economic Perspectives, (1988).
10. The usual argument cited in the literature for not treating these goals explicitly is that they are not consistent with conventional Paretian social welfare functions as applied in welfare economic analysis. As Corden (1974), pp.107-12 has long argued, the case for such conservative welfare functions is really not as strong as some economists would like to believe.
11. Katz and Summers (1989) argue that in the United States, inter-industry wage differentials are attributable to economic rent, and so constitute a potential "carrot" in the international rent-shifting competition. In Harris (1989b) the plausibility of this argument is reviewed.
12. It is difficult to ignore the distributional implications of export subsidies to foreign firms even if employment is an objective of government policy. The social cost of government expenditure in the case of a foreign-owned firm can be adjusted to reflect the leakage of government revenues to foreign equity holders. This means, all other things being equal, that a domestic exporter could receive a higher rate of subsidy than a foreign-owned export firm.
13. To be precise, the desire to subsidize is independent of the value of the conjectural variations used by the two firms. This includes the case of "consistent conjectures" which, in the standard model, leads to the conclusion that no intervention is optimal. See Eaton and Grossman (1986).
14. For the moment, we are assuming no constraint on government expenditures in domestic currency terms.
15. See Corden (1974), ch. 12.
16. As was pointed out to me by Tom Ross, this argument is formally identical to the case of a foreign monopolist exporter facing a tariff in the home market. Brander and Spencer (1981) looked at this question and came to the same conclusion regarding the use of tariffs on foreign importing monopolists as we do regarding the taxation of foreign-owned home monopolists.
17. The issue of product differentiation and product quality would take us down another potential avenue for asymmetric treatment of foreign versus domestic firms. The analysis by Venables (1982) suggests in the case of imported foreign goods, it is possible to construct cases where a tariff should be levied on foreign imports in order to encourage the entry of

domestic varieties. This argument is examined critically in Harris (1989b). Most of what is said about tariffs could also be said about using foreign ownership restrictions as a means to "solve" the product variety problem.

18. A textbook demonstration of this argument is contained in Markusen and Melvin (1984), chapter 17.
19. See Harris (1984).
20. See Markusen and Melvin, note 18 above.
21. If quotas are administratively allocated then the quota rights themselves are a substantial entry barrier. The inward FDI in the home market may occur simply as a consequence of the entry barrier to a potential entrant in the foreign market.
22. Globerman (1990) reviews recent Canadian cases involving foreign takeovers of "high-technology" firms.
23. Taylor (1990) offers a useful and critical review of this literature.
24. See Globerman (1985) for a review of this debate. See also, update in this volume, Globerman (1991) on the same issue.
25. An excellent review of this debate is contained in Graham and Krugman (1989).
26. Caves (1982) reviews the evidence on appropriability. More recent empirical work is discussed in Levin et al (1987).
27. The Heckscher-Ohlin model of trade eliminates all such considerations by assuming that technology in use is identical in all countries — this leads to the empirically implausible outcome that all real factor prices are identical.
28. The monopoly rent argument should not be carried to the point of recommending the artificial creation of domestic monopolies for the sake of creating income. Monopoly power referred to here is a natural consequence of the barriers to entry in the industry. As a means of securing monopoly rents from foreigners it may well be to the advantage of the home country. Policies — such as strategic trade policies that attempt to shift these rents internationally by means of the selective use of policy — suffer from all the potential problems identified in the section on strategic trade policy.
29. This presumes the classic description of the efficient world capital market in which real rates of return are equalized across countries. Recent studies of international differences in the cost of capital suggest, however, that rates of return are substantially different across countries even though capital mobility appears to be high. This puzzle must remain as a potential qualification to the idea that capital does not succeed in capturing some share of national innovation rents.
30. This argument assumes that the international distribution of skilled labour used in R&D is not equal — with some countries having much (the North) and some very little (the South). In the absence of footloose production, technology developed in the North must be used with unskilled Northern labour inputs. The argument that "factor returns in the North will widen

as production tends to become more footloose" is akin to the statement that "at the world level, unskilled labour is relatively more abundant than within the North".

31. A good discussion of the types and sources of these spillovers from a historical perspective is contained in Rosenberg (1982). Globerman (1990) briefly reviews the Canadian evidence on spillovers from foreign MNEs.
32. Recent work by Bernstein (1988) offers some new potential econometric methods for quantification of inter-industry spillovers.
33. See Saunders (1980).
34. See Harris (1989b) for a discussion of this issue and the relevant literature.
35. Krugman (1987) provides an example of one such model.

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DISCUSSANT'S COMMENT

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PROFESSOR HARRIS has herein provided a useful introduction to a set of issues that are of undisputed relevance to Canadian policy makers today. It would be a mistake to characterize his paper as a survey, although it does review the contributions of a substantial number of (other) papers it makes no attempt to be comprehensive. The real value of this work lies in its attempt to push existing theory into important new territory.

The Harris study is really two papers — each of which draws on very different literatures. I will discuss them in turn. Though both papers are concerned with the public policy implications of foreign direct investment (FDI) in imperfect markets, they differ in their assumptions regarding the source of the imperfection. The first supposes that the output markets are imperfectly competitive, the second assumes that there are external effects — "spillovers" — associated with research and development activities and/or production in some industries.

Strategic trade theory literature is built on a foundation laid by another theory — the theory of the second best. When a market is already distorted because it is imperfectly competitive (attributable, in part, to the presence of barriers to entry) it may be possible to raise domestic welfare by imposing a second distortion. In a context of international trade, this second distortion can take the form of barriers to trade, such as tariffs, quotas, or export taxes/subsidies.

This insight has spawned a truly substantial literature that attempts to derive the conditions under which welfare improvements are possible, and to determine the instruments needed to effect such gains. I use the term "substantial" here to refer to the sheer quantity of work in this area; there are scores of papers in this literature. Harris' second section offers a nice summary of criticisms of this work, together with a brief rebuttal.

Researchers have also developed different models of imperfect competition but almost all of them are about rent and surplus shifting. However, rent shifting is not at the core of models that study monopolistically competitive market structures. Here, the concern is with policies that might lead to welfare-improving changes in the number of brands available to consumers. Domestic governments may be able to use trade policy instruments to shift rents from foreign producers and surplus from foreign consumers to domestic firms and consumers, and the domestic treasury.

After a brief introduction to strategic trade theory, Professor Harris proceeds to apply the theory, adding two new elements to existing models. First, he asks how the policy conclusions would change if domestically located firms were owned by foreigners. Second, he considers the impact of altering the objectives of the domestic government: that is, he replaces the familiar domestic surplus maximization objective with objectives related to expanding domestic employment or improving the balance of payments.

To be sure, Professor Harris does not rework all existing theory. For example, there is only limited reference to or discussion of collusion models and models of monopolistic competition, and there is no modelling whatever of the multistage game played between governments, as found, for example, in Brander and Spencer (1985). While the reasons for his selectivity are sound as well as obvious — a complete survey would require a volume of its own — we must keep in mind that his results are more suggestive than conclusive. While he finds little support for an activist strategic trade policy in the presence of FDI, this work is vulnerable to the challenge that he has not considered all the interesting market structures.

In general, Professor Harris' most interesting results emerge when he considers FDI in a model in which governments do not maximize domestic surplus. Instead, he considers FDI as a model in which governments maximize employment or they work to improve their country's balance of payments. It is easy to see why this should be so. When we consider the effects of FDI in a model with surplus maximizing governments, all we do is change the identity of the firms. A domestic firm that is 100 percent foreign owned is really just a foreign firm; knowing this, we can determine the government's optimal policy simply by looking it up in our fat catalogue of existing results. Indeed, Professor Harris recognizes this when he makes the point (in the section titled Foreign Ownership and Domestic Markets) that the analysis of the case of the foreign-owned domestic monopoly is formally identical to that of the foreign monopoly exporting into the domestic market. As Professor Harris recognizes, this is not quite so straightforward when workers earn rents, or when there are positive spillovers associated with domestic production. In these ways, domestic production can be made to matter, even in a framework of surplus maximization.

At the end of this analysis, it is difficult to disagree with the conclusion drawn — that the strategic trade literature (as presented and extended here by Harris) does not appear to include a general case for any particular type of trade intervention. The appropriate policy (e.g. tariff, export subsidy etc.) is therefore likely to be very model-specific — suggesting that the design of a successful activist strategic trade policy would be highly problematic.

One of the best parts of the paper — FDI and Modern Protectionism — makes a related point. Harris asks the question: whether, in markets already distorted by tariff or other barriers to trade, might restrictions on foreign direct investment be (second-best) desirable? Not surprisingly, his answer is, yes, because restrictions *might* raise domestic surplus. Nevertheless, there is no general case for intervention here; in fact, it is likely that foreign investment will be undersupplied.

The second part of Professor Harris' paper has to do with the effects of market imperfections caused by external benefits associated with invention and innovation. The key questions seem to be: does foreign direct investment bring technology in or ship it out, and, should we care?

Considering the second question first, the answer seems to be that we should care. There is evidence that the intensity of technology might be one of the keys to a nation's success at raising income levels. This relationship can have several sources. First, working with better technology implies higher marginal products for workers. Second, the countries that control the best technologies in an industry should be able to earn rents on that knowledge from other countries. Finally, local research and development and/or high-technology production activity might generate external benefits that, to some extent, are captured locally.

As to the first question, it appears that Canada, as a net importer of technology, benefits more from FDI than it loses. The more pressing question is: to what extent does Canada lose when a successful Canadian research-intensive firm like Connaught Labs is taken over by a foreign firm? If all we are worrying about are innovation rents lost to the French, surely our concerns are misplaced — to the extent that these rents are capitalized into the sale price paid to Canadian shareholders.

More troublesome, perhaps, is the question of what the new owner will do with this research operation; will it be moved closer to the firm's other research facilities? If there are local spillovers associated with this research activity, such a transfer could be costly to the Canadian economy. What this discussion could really use is some evidence regarding the tendency of foreign firms actually to move research facilities in this way. While we have evidence of so-called "centralization" effects, these data may be dominated by research ventures launched by the current owner. In my view, there are good reasons to believe that a new owner will not want to risk breaking up a successful team. Given that the major assets of a research group are frequently expressed in terms of human capital, an attempt to move the group to a foreign country could be destructive. (It would also be interesting to know the extent to which centralization of R&D follows the takeover of a foreign firm. Some of the other work presented at this conference might shed light on this, as well other important questions.)

Much of the informal analysis offered in the last three sections of the paper is founded on the North-South model of international trade. As valuable as it is in explaining the growth of other countries, I cannot help but wonder about its relevance for a country like Canada. (I hope Professor Harris and the reader will forgive me if this simply reflects my lack of understanding of this literature.) As I understand it, this model breaks the world into two parts; a wealthy, technology-exporting North and a poorer, technology-importing South. How does one use such a model to guide public policy in a wealthy, technology-importing country like Canada? Even granting that our wealth may come from factors unrelated to technology intensiveness (e.g. our natural resource endowments) it is not at all clear to me that what is appropriate policy for a poor technology-importing country would also be optimal for Canada.

Finally, Harris concludes that restrictions on FDI would be socially damaging. I share the author's concerns regarding the possible results of such an approach; particularly the reduced access to foreign expertise (which raises the expected return to domestic R&D) and the possible retaliation by other countries against Canadian investments abroad. It is also very difficult to envisage circumstances in which the gains from such a policy would be significant.

While agreeing with his conclusions, I think the point should be made that little attention has been paid in the paper to the alternative arrangements that might be made should FDI be restricted. It is as if we expect foreigners just to walk away from the Canadian market. On the other hand, maybe licensing arrangements will become a very popular substitute for FDI. Then the question becomes: does FDI provide more benefits to the Canadian economy than licensing (or other alternative arrangements)? While it is likely that a strong case can be made for allowing foreign firms to serve the Canadian market in the most efficient way possible, that case is not really made here.

In closing, let me say that Professor Harris is to be commended for bringing together so much interesting material and so many ideas into such a readable package. He has opened lines of research that are well worth pursuing.

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2

The Theory of Technological Competence and its Application to International Production

AN OUTLINE OF THE THEORY

MUCH OF THE RECENT THEORISING about the determinants of international production has focussed on the mode by which final product markets are serviced across national boundaries. In this literature, international production, and its financing through foreign direct investment (FDI) is treated as an alternative to open market trade between independent agents in different countries. Leaving aside the exchange of final products (exporting from the home country of the company concerned) the alternative to FDI involves the arm's-length international exchange of intermediate products (including intangible assets such as the licensing of technology to host-country firms). For a given location of production and pattern of international trade, the extent of home-country exports is fixed, thus the central question becomes the way in which transactions in intermediate products are organized. The greater the level of international production, the higher the concentration of ownership of agents linked by flows of intermediate products. The growth of international production is therefore to be viewed as the replacement or internalization of intermediate product markets.

More recently, other new questions have come to the fore. (For surveys of the various theories of international production see Dunning, 1988, and Cantwell, 1990b.) Particular attention is now being paid to the determinants of international competitiveness, and why some firms grow faster than others. While these new approaches share a certain amount of common ground with the internalization theory and other related theories, to address the new issues the new approaches require some distinctive elements. Most notably, the analysis of how competitive or ownership advantages are generated across different firms, and the evolution of these advantages over time, becomes critical. Central to this is the theory of technological competence as a regulator of competitive success or failure. It has been derived from recent advances in the theory of technological innovation as an evolutionary and cumulative process (the origins of which can be traced to Nelson and Winter, 1982; and an extensive commentary on which is to be found in Dosi, Freeman, Nelson, Silverberg and Soete [eds.], 1988).

Technological competence is a relative concept. Basic competence is a condition for survival, but there are varying degrees and types of competence among surviving firms. First, the theory proposes that in any international industry firms with a higher degree of technological competence will grow faster than others, thereby increasing their market shares. Second, the theory rests upon a basic proposition about the nature of technological development — from which a number of associated propositions follow. Third, taken together, these propositions determine the level of technological competence of the rival firms, although they also allow for a stochastic component. Each of these three steps is outlined in turn, before going on to discuss empirical testing, the application of the theory, and its implications for the wider analysis of competitiveness.

THE EFFECT OF TECHNOLOGICAL COMPETENCE ON GROWTH

THE LEVEL OF TECHNOLOGICAL COMPETENCE affects market share(s) through its influence on both unit costs and product quality. Strong technological capability lowers unit costs, improves product quality or range, and thereby raises profit margins of advantaged firms relative to others in the same industry, or it enables them to enter a new market. A firm with comparatively weak capability incurs high unit costs relative to others in its industry and may consequently suffer losses and be compelled to leave markets. This is particularly so when considering the competition between the largest multinational enterprises (MNEs) in an international industry (outside the possibly sheltered domestic market of each) although over the long term, the same is likely to apply to all firms. Such international competition acts to ensure that a significant proportion of profits are reinvested (or a higher volume of borrowing for investment is sustained) so that a higher level of technological competence (and hence profitability) translates into a faster growth rate and thus a rising market share or new market entry, whether by internal expansion or acquisition. This is supported on the demand side by an improved product quality and reputation facilitating a substitution effect among customers away from the more dated products of less competent firms.

The question of the relative growth rates of firms and changing market shares can be addressed in two ways. First, by comparing the growth rates achieved by a cross section of individual firms, and second, by comparing the performance of groups of firms with certain common characteristics. In the second case, a useful grouping can consist of national firms grouped together according to the origins of the parent company. Another might be by firms with a similar sectoral profile of technological activity (given that a variety of strategies for technological specialization is possible in any industry). Any statistical comparison, however, must allow for a stochastic element. Even in terms of purely technological determinants of growth, the outcome cannot be uniquely predicted as the development of a new line of innovation may have unforeseen and unintended effects. The stochastic component is likely to be greater when comparing individual firms as opposed to wider groups.

There are also other factors that contribute to the success or failure of companies apart from their degree of technological competence. Among these are the organizational capabilities of the firm and the entrepreneurial ability of its managers. However, technological considerations are the most directly amenable to analysis, and statistical evidence (discussed below) has confirmed their central role. It should also be noted that the theory of technological competence is not an alternative to a theory of entrepreneurship or organizational form; such managerial aspects of company strength or weakness are clearly interrelated with technological competence. Organizational and technological capability overlap with one another. In making comparisons of technological performance it is important to understand the institutional context in which innovation takes place (as stressed, for example, by Freeman and Perez, 1988).

The theory of technological competence forms part of a broader approach to competitive advantage. This broader approach views firms as having inherent capabilities for expansion, rather than simply responding to changing conditions in external markets. The notion of technological competence, therefore, can be placed in the same tradition as the allied concepts of the inherited resources of the firm (Penrose, 1959); firm-specific central skills and resources (Rumelt, 1974); entrepreneurial culture and the leadership of social groups (Casson, 1988); dynamic organizational capabilities (Chandler, 1990); dynamic capabilities (Teece, Pisano and Shuen, 1990); and core competence (Prahalad and Hamel, 1990). In each case, firms gradually accumulate internal expertise that lowers their costs and creates new opportunities in the process of competition with others.

As will become clear, the term "technological competence" is used here in a broad sense that goes well beyond the output of the research and development function. In this context, technological innovation encompasses *all* changes to the immediate conditions of production which, over time, raise the productivity of inputs and provide for new products. Thus, the operating technology of production is closely interdependent with the organization and management of production, so technological competence is strictly complementary with (and overlaps) organizational capacity and managerial skills. It draws on all aspects of the firm's activity, including feedbacks from marketing — although technological competence does not cover advertising, as opposed to the ability to create new or differentiated products. Hence, the claim that technological competence is a key determinant of competitive success does not mean that the research function is necessarily more important than others, or that technology (in the narrow sense of codified information and patented blueprints) is more important than other influences on production operations (as the overall conditions of production define technology in the broad sense).

The strictly economic (external) influences upon growth can be divided between intra-industry or oligopolistic factors and causes of inter-industry variation (for a full survey see Cantwell and Sanna Randaccio, 1989). The former includes the market power or relative size of the firm within its principal sector, and the extent of international integration it has achieved at a global or regional level relative to its major world rivals. The latter encompasses the growth of demand, the absolute size and the age of the firm, all of which vary across industries. Again, work in these fields is complementary to the theory of technological competence. There is, for example, a separate and well-established literature on the relationship between the size of firm and the intensity of technological activity (surveyed in Baldwin and Scott, 1987). The major conclusion of recent studies is that the association between size and innovation depends upon the nature of the industry and the structure of its linkages between large and small firms; the so-called Schumpeterian hypothesis of a positive relationship between size and innovation holds, if at all, only at an inter-industry level among larger firms (Pavitt, Robson and Townsend, 1987a; Acs and Audretsch, 1987 and 1988).

THE FUNDAMENTAL CHARACTERISTICS OF TECHNOLOGICAL DEVELOPMENT

THE THEORY OF TECHNOLOGICAL COMPETENCE suggests that variations in innovative capability are a result of the nature of technology and the way in which it develops. The central proposition on this issue was first articulated clearly by Nelson and Winter (1982), although its application in an historical context can be traced to the work of Rosenberg (1976 and 1982). It is also consistent with a long tradition of related ideas such as those expressed by Usher (1929) and Atkinson and Stiglitz (1969). The basic tenet is that technology is partially tacit, is specific to the context in which it has been created or adapted (the firm and the location), and is dependent upon the learning and skill of those who have developed and operate it. Technology in any firm is a product of a steady search for improvements and a learning process.

The skillful behaviour required for the generation and application of technology normally becomes embodied in a set of routines that characterise a specific firm, and changes only gradually. These skills and routines are not deliberately chosen from alternatives, but are developed through trial and error and include many elements that are selected automatically. They consist of an interlinked sequence of steps which require tacit knowledge on the part of those who perform them, and which cannot be fully communicated to others unless they join the firm's team and undergo the same learning process. An analogy can be drawn with other individual skills — such as the ability to ski.

Even the trained ski instructor is not fully conscious of all the steps that comprise a skillful performance, and cannot completely articulate them for a beginner. The novice must instead learn by doing, through practice and criticism, building up and combining a series of actions, many of which are selected automatically rather than through deliberate choice.

The tacit component of skills and routines is greater still where learning is a collective process, in which an individual contribution is developed through interaction with others. Many collaborative skills and routines cannot be reproduced by an individual operating alone, because they are tied to the team and its current operating environment. Some of the common understandings on which they rest are tacit, have evolved through trial and error, and are difficult to explain to outsiders.

The basic proposition is that technology always consists of two elements: the codifiable and the non-codifiable. The first element comprises information, patented blueprints and other codifiable knowledge. Much of the literature on the economics of technological change defines technology in a narrow sense, restricting it to this element and disregarding the second (for a criticism of which see Dosi, Freeman, Nelson, Silverberg and Soete [eds.], 1988; or Mowery and Rosenberg, 1989). The second element is tacit, and involves the non-codifiable elements of the skills, routines and operational practices that accrue from learning processes.

The basic proposition also implies that the two elements of technology are strictly complementary; one cannot function without the other. The relative significance of the two elements may vary between industries or types of technological activity. To a lesser extent they may also vary over time, and to an even lesser extent still, across firms in the same sector. However, for a given sector of activity over reasonably short time periods, the relationship between codifiable and non-codifiable components required to make technology operational can be regarded as essentially fixed.

In principle, the first element of technology is tradeable between firms, although this does not imply that the process of transfer is easy. Even codified knowledge or information is context-specific and is likely to be set out in terms of the standards or codes established by the originating firm and which must be translated into those of the recipient. The ability of the receiving firm to acquire and process new information and to appreciate its significance — the firm's "absorptive capacity" (Cohen and Levinthal, 1990) — depends upon its existing technological capability. In addition, the cost of learning also includes the creation of the complementary non-codifiable element needed to make the technology work.

Building a supporting structure of skills and routines must be done essentially in-house because the second tacit element of technology is non-tradeable by virtue of its non-codifiable nature. Indeed, of the skills, routines and production experience which it has built up, it may be difficult for the firm itself to specify which areas are critical to the success of a technology. This "causal ambiguity" (Dierickx and Cool, 1989) is closely related to the automatic nature of skills and coordinated routines, of which the various steps do not each have a consciously planned role. The non-codifiable element of technology can be imitated by other firms (with or without assistance, where the first element has been traded) but it can never be exactly copied. The learning process is never exactly the same if repeated; it depends upon the initial capabilities with which the firm begins and which it adapts in the development of a new technology.

One implication of the necessary inclusion of a tacit element is that firms do not develop or adopt technology by maximizing some objective over a given choice set. According to Nelson and Winter (1982), since learning a new technology involves a series of automatic steps, it cannot be depicted in terms of any deliberate choice, still less a maximizing choice. Skills and routines are acquired and exercised with reference to a particular environment, but such an environment is complex and changing. For this reason a firm that is able to maximize its operational efficiency at any time does not behave in a dynamically efficient fashion. The options selected in the development and operation of technology are not deliberately chosen, and allow for error or mistakes. However, a firm or species that makes mistakes generally out-competes a perfectly reproducing rival, because diversity and variability (and making mistakes) are essential elements in successful learning. A firm that searches along some initially unpromising avenues may, by developing the relevant skills and routines at an early stage, gain by becoming more adaptable to changes in the underlying technological opportunities and through an easier appropriability of returns by being more able to forge areas of technological leadership. This is so even if certain of these unpredictable avenues must later be abandoned.

To reiterate, the basic proposition is that technology is partially tacit and context-specific. From this, six allied propositions follow. The first three have been proposed by Pavitt (1988) as comprising a theory of technological accumulation; the fourth and fifth feature prominently in the work of Arthur (1989); while the last is associated with Freeman (1979) and Dosi (1983). A further discussion of certain aspects of these propositions and a somewhat different formulation of them can be found in Dosi (1988).

The first proposition is that *technological innovation is a cumulative process*, partly as a consequence of the gradual learning and establishment of locally-refined skills and routines upon which it depends. Learning is itself cumulative, inasmuch as the capacity for learning depends on the complexity of what is already known. The prevailing routines of a firm define the possible paths for new developments, and the routines only change slowly through careful experimentation. Technology is thus created and installed in production methods through learning by doing, learning by using, and building on what has already been achieved. Cumulativeness also results where one advance gives rise to or inspires others in the same field of activity. Apart from the possibility of extending the applications of a new technology, further development may be required due to the need for critical revision. For example, the construction of the steam engine led to complementary inventions which ensured a greater capacity and the creation of rotary motion, and upon which the subsequent usefulness of the engine itself depended (Usher, 1929). In shipbuilding, the design of propellers and the material from which they are constructed changed gradually as technological opportunities evolved. It was these improvements that made possible the effective introduction and diffusion of screw propulsion rather than the original invention of the propeller itself (Gilfillan, 1935, cited in Rosenberg, 1982).

The second proposition is that *innovation proceeds incrementally*. Firms therefore tend to move forward gradually between related types of technological activity. That is, one advance leads to others in related fields, or each advance requires the development of supporting technological systems for its effective implementation. Each firm sets up its own search procedure, which comprises problem-solving activity arising from existing practices, in which the solution to one problem raises others and technological development therefore gains a certain momentum of its own. A breakthrough in one area becomes a "focussing device" in the search for complementary technologies in related areas. For example, technological advances in the speed of transport vehicles gave rise to efforts toward improved braking systems (Rosenberg, 1982). In fields of limited technological opportunity, companies frequently move backward into related materials or process technology (Pavitt, Robson and Townsend, 1987b). As a result firms may become more technologically diversified, or the focus of their specialization may switch. Although the underlying technology and skills continue to build upon the past, the industrial applications may gradually change. In particularly extreme cases this can result in the formation of new industries. Another kind of incremental change that is not internally sequential may follow from a shift in technological opportunities or the availability of inputs; such as the transition of IBM from mechanical calculators and typewriters to computers, and the development of synthetic fibres by textile firms. Such transitions are more difficult in terms of the adaptation of existing skills and routines, but the ability of the firm to undertake it depends on the extent of the technological connections between the old and the new activity.

The third proposition is that *technology is differentiated between firms and locations*, given that it is specific to the context in which it is created. Even where there is a convergence or catching up effect, there is never exact replication or copying. The path of technological innovation followed by a particular firm or group of firms in a given research centre is distinctive, and is marked by certain unique and characteristic features, which include and reflect the tacit element of technology. The skills and routines established by each firm are not identical, partly because the process of search and learning requires variety. The composition of technological activity in each firm is also different, reflecting their separate even if interconnected traditions. One aspect of this is a diversity of patterns of technological specialization across firms. For example, among pharmaceutical companies with similar product ranges some rely relatively more on techniques derived from industrial chemistry while others draw relatively more from biochemistry. National groups of firms are likely to be more similar to one another in this respect than they are to other international rivals, due to the common elements in their historical traditions. The characteristics of innovation in a given location depend upon the strengths and weaknesses of the local educational system, the linkages between firms, the nature of business practices, and the local institutional infrastructure and government policy. The transfer of technology between countries or firms therefore involves costly adaptation to local skills, routines and engineering capabilities. Technology transfer is so distinguished from imitation by degree rather than by kind.

The fourth proposition is that *technological change is partially irreversible*, in two senses. First, once technology and the accompanying skills and routines have moved forward, previous or simpler technologies are "forgotten". To reintroduce them would require a new learning process and the adaptation of individual skills and organizational practices. Once again, technologies are not deliberately chosen from a wide range of possibilities, but are locally specific. However, the previous technological course of each firm or related group constrains the current search procedure, even to the point, in some cases, of preventing turning back. Second, technological development is frequently nonergodic in the sense that more than one outcome may have been possible but, at some point, the path or trajectory becomes established and earlier alternatives are excluded; in other words, it is a path-dependent process (Arthur, 1988). This form of irreversibility is potentially inefficient, as for example, when alternative systems possess genuine technical advantages. This was the case when the gasoline engine won out over the steam engine and, more recently, when the VHS video recorder gradually displaced the Sony Betamax (Arthur, 1989). As well as being "locked in" to a path, firms may also find themselves "locked out" of fields in which there are strong cumulative gains if they do not invest sufficiently early (Cohen and Levinthal, 1990).

The fifth proposition is that the *specific path of innovation in each firm and at each location is constrained by a system of technological interrelatedness between companies and types of activity*. This interrelatedness between types of technological activity is one of the conditions for incremental change (the second proposition). Interrelatedness between companies is also an influence on the irreversibility of change (the fourth proposition). Within the firm economies of scope are achieved by carrying out technologically-related activities (Teece, 1980, 1982), while the firm can draw on the complementary technologies of others outside the firm and develop an interaction with trading partners or firms in allied sectors. It should be noted that firms and industries that are quite unrelated by the nature of their final products or through product transactions can become closely related on a technological basis — firearms, sewing machines, bicycles and motor vehicles for example (Rosenberg, 1976). Interrelatedness between firms is an especially important influence on the locational specificity of innovation, as it may be costly to change the prevailing methods in an individual firm or sector without complementary changes elsewhere. Such collective shifts in technology, to some extent lie outside the control of any particular firm. Another aspect of interrelatedness is the effect of the decisions of the earliest adopters of alternative technologies on the direction of firms that come later, through encouraging the development of a supporting infrastructure of complementary technologies, thus lowering the costs and increasing the benefits of adopting a type of technology which is already more widely diffused (Arthur, 1989). Followers gain from the experience of "learning by using" by established firms, from the network externalities associated with greater availability and variety, and from increasing returns in information about the technology as it diffuses.

The sixth proposition is that *the direction taken by the search processes of firms and the rate of innovation they achieve is governed by the underlying growth of technological opportunities*. This depends upon the prevailing technological paradigm, however. A technological paradigm is defined as a widespread cluster of innovations which comprise a response to a related set of technological problems based on a common set of scientific principles and on similar organizational methods (Dosi, 1983 and 1984). A technological paradigm is a consequence of interrelatedness in problem solving activity between firms and industries, and of complementaries between fields (the fifth proposition). Each major upswing in innovation across firms tends to be associated with the emergence and consolidation of a distinctive new technological paradigm, which allows for rapid advances in certain types of technology for a variety of firms (Freeman and Perez, 1988). However, it also follows that the growth of technological opportunities and the ease of appropriability is greater for some firms than for others. Firms specializing in areas where technological opportunities are rising faster achieve higher growth, while firms specializing in other areas find it difficult and costly to make the necessary adjustments, due to the specificity of technology, skills and routines. Their ability to adjust in any location will depend, in part, on government policy and the local institutional infrastructure.

THE DETERMINANTS OF TECHNOLOGICAL COMPETENCE

SINCE TECHNOLOGY IS DIFFERENTIATED ACROSS FIRMS, the specific elements of the technology, skills and routines of each firm are what provide it with its essential competitive or ownership advantages vis-a-vis its major rivals. Each major firm in an international industry has facets of technological leadership which are not easily imitated by other firms, given the somewhat different path of their innovative search activity. This occurs because differentiation is grounded on the partially tacit and cumulative nature of technology in which each firm establishes its distinctive area of competence and does not represent a deliberate choice from a set of technological possibilities available to all firms. The more cumulative that technological development is and the faster technological opportunities grow in any sector, the greater the dispersion of ownership advantages or competence across firms is likely to be.

The spread of competence across firms in an industry also depends upon the selection environment (Teece, Pisano and Shuen, 1990). A tight selection environment, made so because of a slow growth of demand, for instance, may result in few survivors with a narrow range of competence among them. Selection environments differ in the variety of types of competence which they are able to sustain (firms with different technological backgrounds or traditions), and in the ease with which they facilitate new entry. New entry tends to be easiest when there is a shift in the prevailing technological paradigm, when new areas open up, and when the rate of growth of technological opportunities in existing sectors changes. If leading firms consolidate their position where development is cumulative, the change in the pattern of competence and growth may become more nearly stochastic during a paradigm shift. However, windows of opportunity may be open for only a short time before firms find themselves locked out of a new area, or consigned to a limited role.

To reiterate, technological competence or advantage does not consist simply of a set of blueprints over which a firm exercises a temporary monopoly. Technological competence at the firm level comprises all those components of the methods of production that are differentiated and thus characteristic of the firm in question. It includes the whole of the tacit element of technology embodied in the skills and routines of the firm, and the reflection of that element in the common codes and standards of the firm and its particular specification of tangible assets. The tacit element is by definition specific to the individual firm, while there are certain aspects of the codifiable element which are also unique to any firm. Technological competence is not the sole product of a firm's research and development division, or any single functional department whose role varies between firms. Rather, competence or competitive advantage is the result of the common learning process that binds the different departments together, creating a specific technological tradition within the firm. Increasingly, technological development relies on the support of a well integrated team (Freeman, 1990).

Technological competence provides a sustainable competitive advantage because it is based upon the tacit element of technology which cannot be traded between firms nor substituted for the codified element that can be traded. Although this tacit element can be imitated by other firms, it can never be exactly copied, given their somewhat different technological traditions as represented by their specific skills and routines. Moreover, imitation takes time and involves a costly learning process. Skills and routines can be developed only gradually, over time, and through accumulated experience. Other than where new fields or industries open up, firms generally need an existing expertise in a related area in order to imitate successfully.

Technological competence closely overlaps and interacts with other firm-specific considerations, such as marketing capability and the organization of the firm as a whole. Technological competence also encompasses the skills and routines developed in production and research, which are directly associated with the methods of production (the firm's technology). This is, in turn, linked to the management structure of the firm and to the co-specialized assets which typically lie downstream (Teece, 1986) in marketing, distribution and after-sales service. The interaction between technological competence (embedded in the production operations of the firm) and the operation of co-specialized assets (marketing, etc.) helps to reinforce the features of technological development outlined above; for example, encouraging incremental change and related diversification to enhance the value of an existing distribution network.

Indeed, it is possible to treat all firm-specific capabilities as possessing essentially the same characteristics as technological competence and as an extension of it. The organizational capabilities of the firm consist mainly of the routines which contribute to technological competence, but also of the overall management and coordination of diverse types of activity (with different routines). The other capabilities of the firm (in addition to its overlapping organizational and technological capacity) are associated with the operation of its co-specialized assets. These dynamic capabilities considered as a whole have a tacit dimension (Teece, Pisano and Shuen, 1990), which is related to the tacit element of technology, and provides a non-tradeable competitive advantage attributable to a process of learning and experience.

Where a firm establishes technological leadership in a field that is important to others (particularly when others have previously neglected an innovation as being impractical, or when their earlier search efforts have been unsuccessful), competitors attempt to catch up or to imitate the leader. The ability to catch up depends on having capability in closely related types of activity. Given that this exists, imitation is generally more likely than the purchase of technology from the leader. Imitation tends to be favoured over licensing because the valuation placed on its own (specific) technology by the leading firm is typically higher than the value placed on it by a rival. The leader already has the supporting structure of relevant skills, routines and complementary technologies required for the effective implementation of the technology, while other firms must adapt their skills and practices to fit the new technology. If a rival firm is to remain competitive, it must bear the costs of setting up its own alternative technological system more akin to its own tradition in any case. Also, the tacit knowledge thereby acquired serves to reduce the additional costs of inventing around patent protection. Much of what is common to the existing technology of the leading firm and the new technology to be created by the imitator is already in the public domain through the availability of patented blueprints and informal contacts between scientists and engineers.

As a result, firms tend to develop and operate technologies internally that are central to their basic competence, to which they attach a very high value, but which typically are of only limited value to other firms because these other firms have their own differentiated areas of expertise. The high valuation placed on a new technology by the firm that created it applies especially when that firm can operate in several locations — thereby widening the differentiated scope of its own technology, skills and routines to fit the requirements of producing in a variety of locations and expanding the core of its technological competence and its capacity for future innovative development. Particularly in industries in which MNEs can adopt internationally integrated strategies rather than nationally responsive strategies, what is learned in one location may be useful in another.

The emergence of new technological opportunities changes the pattern of technological competence across firms. At the level of individual firms, increased opportunities in their established fields allow leaders to raise the level of their technological superiority relative to weaker firms trying to catch up. Against this, a growing number of opportunities in a related area may undermine such leading firms if they have potential competitors with the appropriate specialization. Because of the cumulative, differentiated and irreversible nature of technological development, firms become locked in to a particular path of innovative activity, and may be able to shift only gradually or incrementally toward fields in which technological opportunities are rising more rapidly.

Former leaders sometimes make a successful transition. Their ability to do so is greater where their competitors are weaker, potential entrants into new fields are fewer, and where the areas of new growth in technological opportunities are closely related to their original source of strength. Former leaders may also be helped when they are (among) the first to identify and shift towards a new sector. Alternatively, if the new field is highly experimental in the early stages, the first movers may suffer disadvantages (Ames and Rosenberg, 1963), and established leaders in related areas may enter through the acquisition of an overstretched pioneer whose skills, routines and codified knowledge can be adapted in line with its own and thereby integrated. During periods of shift in technological paradigm it is likely to be easier for individual firms to switch between sectors of activity than it is for countries.

At the level of national groups of firms or locations, the sectoral pattern of innovation is even more likely to become locked in — irrespective of where technological opportunities lie — owing to the additional constraint imposed by interrelatedness between firms and with other institutions. The pattern of comparative advantage held by each national group of firms in the creation of technology, and the stability of that pattern over the medium term as the sectoral composition of activity becomes locked in to a particular course, influences the rate of innovation achieved by each national group (Cantwell, 1990a). American firms historically, and Japanese firms today enjoy a comparative advantage in sectors in which technological activity has been growing fastest. This has helped them to sustain faster growth rates while former technological leaders have had to meet the heavy costs of moving toward the areas in which opportunities have been rising most rapidly. Which industries offer the greatest technological opportunity is influenced by the prevailing techno-economic paradigm that characterises innovation and organizational practices in each historical period (Freeman and Perez, 1988).

For example, prior to 1914 British firms were locked in to innovation in sectors with few opportunities, such as textiles, shipbuilding and heavy mechanical engineering (Cantwell, 1990a). British companies were often left behind in science-based areas, due to the difficulties of institutional adjustment as well as the cumulative technological advances made by leaders elsewhere. In the case of industrial chemicals, the deficiencies of the educational and training systems and their weak links with industry resulted in a shortage of highly qualified scientists and technicians (Haber, 1958; Liebenau, 1984). Besides being locked in to innovation in sectors with few opportunities, British firms also found themselves locked in to dated institutions and organizational practices, associated with outdated routines that affected their performance adversely in all sectors. Their inability to adapt quickly especially hampered their capability in the science-based sectors, where technological opportunities were greatest.

However, changes in international technological leadership are not frequent, usually taking place only during shifts in the dominant technological paradigm, based on a radical restructuring of the fields of the fastest growth in technological opportunities. At other times, leading firms are likely to consolidate their position cumulatively in their differentiated areas of strength. National groups of firms that lie behind the technological frontier tend to catch up fastest, or to fall behind more slowly in those sectors in which they are comparatively advantaged in innovative activity or, in other words, closest to the frontier.

Within an international industry, those firms that are specialized in the areas of most favourable technological opportunities tend to grow faster than others. The distribution of competence may occasionally shift with the technological paradigm, however. Consider, for example, the pharmaceutical industry. As in other industries, during the Victorian period British firms lost their leadership owing to their concentration on a scientific tradition that lay outside the mainstream. The British strength emanated from medical and biological research, as represented by the innovative activities of the Evans Medical Company, the Lister Institute and the Wellcome Company. This left them lagging in the area of pharmaceutical research that spun off from the chemicals revolution led by German firms that began with artificial dyestuffs. However, this may also help to explain the recent British revival in pharmaceuticals innovation, building upon past traditions which were, to some extent, preserved at a time when opportunities are increasingly emerging from biotechnology rather than chemicals.

Variations in the growth of technological opportunity across sectors, or between fields in a given sector, alter the spread of competence over firms and locations. Firms that consolidate their differentiated strengths or competitive advantages, and countries with the appropriate technological specializations, tend to gain. The remainder of this paper examines the international implications of firms and countries being locked in to their own specific course of technological development. It looks at the interaction between the distinct competitive advantage or technological competence of firms and the specialization or pattern of competence of countries.

I begin by by reviewing the application of the theory of technological competence to empirical studies of international competition, and include a brief comparison with other approaches to international production. Next, I consider the implications for international corporate research strategies of the technological specialization of locations and of the local interrelatedness between companies based in the same country. These factors help to determine whether MNEs require a local research presence in a given country. The next section extends the analysis to consider the impact of the growth of MNEs on the competitiveness of countries and the scope for national policies to influence the local retention of competence. The final section further examines how international technological development may affect the distribution of research related production between countries, how it may enhance the distinctive specialization of locations, and considers how policy makers might react.

THE APPLICATION OF THE THEORY

AS OUTLINED SO FAR, the theory of technological competence is a general theory of competition and growth and does not apply specifically to international production. Most other recent work on MNEs, likewise, tends to apply broader theories of the firm or the industry in an international context. In this case the extension is an obvious one when dealing with competition between the world's largest firms, in view of the creation of international industries. The assessment of competitiveness, which at the level of firms relates to specific advantages associated with specialized areas of technological competence, must be judged in relation to the strengths of other world leaders. The competition between major rivals outside their domestic markets is organized through international production and exports. Note that the theory applies equally to firms other than the major MNEs, but in their case the emphasis is on the growth of domestic production rather than international production — which is not the subject of discussion here. However, the theory also pertains to an explanation of how this international dimension has come about for the leading companies, through its contention that innovation is location-specific as well as firm-specific.

Given that technological competence is treated as a central regulator of competitive success, the theory involves each firm organizing its activity not only to exploit its existing field of competence, but also to enhance the future development of its technological capability. The firm-specific nature of technology ensures that it is normally more efficient for a firm to extend its own network with its allied skills and routines than to license its technology to other firms with different traditions. By doing so it also retains the capacity to generate new technology more effectively, since the extension of activity allows for a more diverse search procedure and relies on the development of a broader set of complementary technologies and skills. This requires the internalization of at least those research and production facilities that are germane to the firm's strategic advantage or its core technologies.

In addition to the need for the direct control of its principal technologies to ensure their effective operation and the future capability of the firm, the location chosen for each new facility is important. The location-specific aspect of technology provides an incentive to the establishment of international production across a variety of locations to support the capacity of the firm for further innovation. Owing in part to the presence of interrelatedness between firms and other institutions in any location, technological development tends to become locked in to or focussed on certain sectors or fields of activity. The MNE can broaden its technological search procedure by tapping into the different specializations of several locations. Especially in industries in which strategies of international integration are feasible, the geographical composition of the firm's research-related activity is configured so as to increase its capacity to generate new technology. Apart from helping to explain why the international production networks of some firms grow faster than others, the theory contributes to an understanding of why these networks have tended to move towards greater affiliate specialization over time.

To test the theory, and make it applicable to quantitative or statistical studies, technological competence must be measured. The measurement of competence at a given point in time is an indicator of the firm's or country's potential for future growth. The measure depends in part on whether the concern is with competition between individual firms or between broader groups possessing common characteristics. Two measures derived from patent statistics have been proposed to cover each of these cases. In principle, other types of data, such as those on research and development expenditure or employment, could be used to construct similar measures. However, the great advantage of patent data is that they permit a detailed sectoral disaggregation of technological activity, which is critical to the application of the arguments advanced above. A further discussion of the use of patent data as a measure of technological activity can be found elsewhere (as surveyed, for example, by Pavitt, 1987, and Acs and Audretsch, 1989).

Patent or other similar data measure the codifiable element of technology, not the tacit element, which is very difficult to measure directly. This is legitimate if, as argued earlier, these two elements are strictly complementary and cannot be substituted for one another. It is true that the relationship between the codifiable and non-codifiable components of technology varies across sectors, and the proportion of codifiable elements that are patented also varies across sectors.

This must be taken into account by only comparing firms within the same sector of activity. It is also true that it is more difficult to measure technological competence for service firms. Service firms are typically the users rather than the originators of the tangible part of technology, so the codifiable elements of their systems are less likely to be patented and they often rely on information technology for which patenting is a poor measure. For this reason the measures discussed here focus on manufacturing and resource-based firms, even though in principle the theory could be extended to cover competitiveness in services.

Groups of firms can be assessed from the perspective of their comparative advantage in innovative activity — that is, the sectors in which they have their greatest potential for growth. The measure of this comparative advantage is known as revealed technological advantage (RTA). The RTA of a national group of firms varies across sectors, and is defined as their share of patenting in any sector relative to their share of total patenting in all sectors (Soete, 1987). The average value of RTA is approximately unity for large numbers of patents, with advantaged areas of activity represented by values greater than one, and disadvantaged areas assuming values less than one. The comparison requires data from a country, such as the United States, in which all the national groups under consideration patent regularly. The RTA measure also has some relevance when investigating the overall potential of national groups of firms for growth since, as argued earlier, those that are comparatively advantaged in the fields of greatest technological opportunity have the capability to expand more rapidly. To illustrate, the RTA index for national groups of firms in 1972-82 is shown in Table 1. It can be seen here, for example, that Japanese firms have an advantage in the electrical equipment and motor vehicle sectors.

A more up-to-date international comparison of potential growth rates applicable at the level of individual firms can be obtained through a measure described as technological competitiveness (TC). This is a more direct measure of technological competence. For a particular firm the value of TC is given by its share of patenting of the leading world companies in its primary industry, relative to its share of global sales by the same firms (Cantwell and Sanna Randaccio, 1989). In this case, an adjustment must be made for the high propensity of American firms to patent in their home country by dividing each company's patent-to-sales ratio by the overall patent-to-sales ratio of the relevant (American or foreign) group in the total of all industries. This method applies to competition between the world's largest firms, measuring the competence of each firm relative to its major rivals in the same international industry. Again, a TC value greater than unity represents an advantaged position and, therefore, an expectation of faster growth.

Depending upon the objectives of the analysis, the TC measure can also be applied to groups of firms, and the RTA measure may be useful to the comparative study of individual firms. The technological competitiveness of a group of firms in a selected industry would be measured by their adjusted patent-to-sales ratio relative to all firms in the same industry. At the level of

TABLE 1

THE REVEALED TECHNOLOGICAL ADVANTAGE INDEX FOR A 12 SECTOR DISTRIBUTION, 1972-82

	U.S.	WEST GERMANY	U.K.	FRANCE	ITALY	JAPAN
1. Food Products	1.09	0.60	1.12	0.83	0.70	0.96
2. Chemicals	0.91	1.17	1.04	1.04	1.29	0.89
3. Metals	1.08	0.89	1.02	1.08	0.85	0.81
4. Mechanical Engineering	0.97	1.10	0.96	0.96	1.18	0.79
5. Electrical Equipment	1.01	0.85	0.98	1.09	0.82	1.30
6. Motor Vehicles	0.93	1.19	0.99	1.03	0.82	1.10
7. Other Transport Equipment	1.01	1.07	1.27	1.31	0.85	0.88
8. Textiles	0.92	1.23	1.24	0.92	0.79	0.94
9. Rubber Products	1.01	1.06	1.09	0.96	1.06	1.11
10. Non-metallic Mineral Products	0.99	0.85	1.42	1.06	0.71	1.00
11. Coal and Petroleum Products	1.32	0.64	1.36	1.42	0.66	0.72
12. Other Manufacturing	1.05	0.85	0.88	0.85	0.77	1.21

SOURCE: Cantwell (1989)

individual firms the RTA index can be employed to depict the sectoral structure of their technological activity relative to other firms in the same industry. This may be a useful adjunct to the overall TC measure as it provides a means of assessing the future evolution of technological competence (the TC index itself). Firms specializing in fields in which technological opportunities are rising most rapidly are likely to see their value of TC increase.

Using such measures, some empirical tests of the basic aspects of the theory of technological competence have been conducted. It has been shown that among the world's largest firms, technological competitiveness in 1969-72 contributed significantly to the growth in sales and hence the change in international market shares achieved between 1972 and 1982 (Cantwell and Sanna Randaccio, 1989). It has further been shown that as a general rule the sectoral distribution of technological activity of national groups of firms or locations becomes locked in to an established pattern over periods of 20 years or so (Cantwell, 1990a). This in turn helps to regulate variations in the rate of generation of new technology between national groups or locations, in accordance with the fields in which technological opportunities are rising most rapidly. In terms of international production, the sectoral composition of innovative activity of American, British, German and Japanese firms (their cross-sectoral RTA index) was a significant determinant of the sectoral pattern of their international economic involvement in 1982 (Cantwell, 1989). Certain other relevant empirical findings are also discussed below.

The technological competence theory is not necessarily incompatible with other technology-based theories of the MNE, such as the internalization theory of the firm or industrial organization approaches. Differences between the theories are largely a consequence of the distinctive issues on which they have chosen to focus. The theory of technological competence is designed to address the questions of why some firms grow faster than others, and how the competitiveness of firms interacts with the competitiveness of locations. For this reason the emphasis is on the analysis of technological competence or ownership advantages across firms, the influence of international variations in technological specialization on the geographical strategies of firms, and the interaction between the growth of firms and the development of locations. Besides looking at the growth of firms, the theory therefore provides a framework for examining the impact of MNEs on host countries and the evolution of the international division of labour. This is considered in a later section.

The most obvious overlaps between theories occur over the issues of the internalization of technology within the firm and the extent of technological cooperation between firms. By emphasizing the firm-specific characteristics of technology, the competence theory suggests that there can be no feasible market for the core technologies of a competent firm since it places a much higher value on them than any potential licensee, which would have to bear the costs of adaptation. There need be no opportunistic behaviour or lack of trust between the firm and a potential licensee; the technology is simply worth less to the licensee. The specific or localized features of a firm's technology are largely non-codifiable and, in any case, even the codifiable part is of limited value to other firms which need to develop their own structure of complementary skills, routines and supporting technologies if they are to introduce their own equivalent. For this reason the need for secrecy, which is sometimes stressed by writers on the subject, is unlikely to be an important motive for internalization of technology in place of licensing or exchange. Those elements of technology that are codifiable and common to competing firms tend to enter the public domain through various channels anyway, irrespective of the number of transactions with other firms. To the degree that secrecy is a cause for concern, companies attempt to inhibit the flow of information within as well as outside the firm.

Technological competence, then, because it consists of those elements of a firm's technology which are distinctive, is never itself transferred through trade or copied exactly through spillovers to other firms. Trade is at least partially possible in technology that lies outside the core activities of the originating firm, since the innovator would have to bear the costs of diversification to realize its full potential. Such trade involves the transfer of certain of the codifiable elements of the technology concerned, usually supported by assistance in the development of the tacit systems required to make it operational. The provision of technical assistance is normally the most important part of the contract to the recipient firm. The objective is to build up similar skills and routines to those established in the originating firm, but adapted to its own specific traditions, and reflecting the different nature of its producing activity in a related sector or market.

Not all the codifiable elements of technology are transferred under such exchange agreements. Even some of the tangible assets are idiosyncratic or specific to the firm, linked to its particular capabilities (Williamson, 1975, 1979) or skills and routines. These are of little value to outsiders, and indeed their presence simply makes it more difficult for other firms to construct similar systems. In addition, the codifiable elements that are transferred embody codes and standards specific to the originator, and which must be translated into the codes and operating systems of the recipient. This, of course, becomes especially difficult where the transfer takes place between distant locations as well as between companies. For example, when the British plans for the jet engine were supplied to American firms during the Second World War, it took no less than ten months to redraw them to conform to American usage (Arrow, 1969, cited in Mowery and Rosenberg, 1989).

There can be no trade in technological competence, only its imitation through gradual learning processes in other firms, with or without assistance. For this reason, comparisons with a notional market are not relevant to an understanding of why the tacit elements of a technology are exploited internally and give rise to the growth or extension of the firm's own production facilities. The question of why the firm exists as against a set of independent intermediate product markets is of little interest in this context. This major source of growth is internal to the firm, not external as might be supposed from some of the internalization literature. The tacit elements of a technology are non-tradeable because they must be acquired by learning rather than through trade, and the firm-specific parts of the codifiable elements are not traded because they are of little value to other firms. The lack of trade in these areas is therefore not attributable to the replacement or failure of any external market.

The main reason for the internalization of core technologies is the characteristics of technology itself and the specific or localized features of its development, rather than the characteristics of the market or the exchange of technology as such. In this respect, the technological competence theory is most closely related to the theory of growth of the firm (Penrose, 1959). The emphasis in both is on the internal competitive advantages of firms vis-a-vis their major rivals, which constitute an inherent potential source of growth. This potential cannot be utilized outside the firm, but is tied to its own particular path of technological development. Moreover, it cannot be exactly copied by other firms, only imitated if they have related strengths of their own.

Spillovers of technology to other firms occur where they have the capacity to imitate the tacit elements, having picked up the codifiable elements partly through informal contacts and the monitoring of public channels. Spillovers can thus be obtained at a cost, where the extent of the cost depends upon the firm's own past experience. The more closely the technological competence of the recipient and originator are related, and the stronger and more sophisticated the competence of the recipient, the lower the cost. The existing competence of the firm is therefore a measure of its receptivity to useful and complementary technological development elsewhere, both in terms of its capacity to imitate them and actually to perceive their relevance in the first place (Cohen and Levinthal, 1989, 1990). Even the ability of a firm to understand the codifiable elements of the technology of another firm is a function of its own competence (Mowery and Rosenberg, 1989). The investments in basic research required to be aware of and assimilate opportunities from the environment may be heavy (Rosenberg, 1990). If the firms are more distantly related, it is possible that the research and development costs of imitation may be greater than the original costs of innovation (Mansfield, Schwartz and Wagner, 1981).

Success in capturing spillovers is not simply a matter of being better informed or luckier than rivals (although there may well be a stochastic element involved), but rather to a better interpretation of available information and an ability to imitate skills and routines in accordance with an existing related competence. Spillovers occur mainly between firms in related fields, each borrowing from the other in the areas of technological overlap between them. Firms have an interest in facilitating the informal contacts and mutual assistance which tends to grow up between companies in any location. The willingness of firms to exchange information freely in this way is due not only to the benefits of reciprocal cooperation (Baumol, 1990) but also to the difficulty for any competitor to build up the accompanying non-codifiable skills and routines outside its own core activities, in a way which impinges more directly on the operations of the originator. In other words, the use to which technology is put by firms in a related field tends to be slightly different, and is in line with their own specific experience.

This helps to explain technological cooperation between firms. Generally, the concern over appropriability which is emphasized in much of the literature on the economics of technological change (Arrow, 1962) becomes much weaker. Spillovers are greater where the appropriability of the codifiable elements of technology, as measured for example by the effectiveness of patent protection, is weaker. It has been shown that where appropriability measured in this way is lower, the intensity of innovation actually rises in the science-based sectors (in which the cost of learning is highest) (Cohen and Levinthal, 1989). In other words, in sectors in which cumulative learning and the imitation of the tacit elements of technology are particularly difficult, spillovers of codifiable information are an incentive (and not a disincentive) to in-house technological development in the relevant areas. Its own competence determines the ability of the firm to capture spillovers where they are potentially available. The greatest inducement to invest in an enhanced competence or absorptive capacity arises where the tacit element of technology is especially significant and difficult to imitate, but where the codifiable element is more freely available and therefore more difficult to protect.

By reconciling the accumulation of a largely non-codifiable technological competence with the exchange or spillover of codifiable elements, the theory also allows for the effects of interrelatedness between the trajectories of innovative activity pursued by different firms. It has been argued (Dunning and Cantwell, 1991) that such interrelatedness is increasing as a shift toward more complex technologies requires the operation of a broader structure of supporting systems even in highly specialized firms. If so, this helps to explain not only the link between technological competence and internationalization (as a means of broadening out the diversity of a firm's search procedure), but also an increase in technological cooperation between firms in fields outside the core strengths of each. The need for cooperation to exploit greater interrelatedness is further increased by the constraints placed on the course of technological development within the firm, which compel it to specialize. In this respect the technological competence theory overlaps with the analysis of collusion, although from a rather different perspective than some advocates of a market power approach. Cooperation is frequently associated with oligopolistic rivalry, where the technological base on which firms must draw is very wide (Chesnais, 1986). If the idea of technological competence is allied to the theory of the growth of the firm, it also suggests a framework of industrial dynamics as opposed to the conventional structure-conduct-performance paradigm (Carlsson, 1987). Consistent with this perspective, the hypothesis that market power encourages (or discourages) innovation has been increasingly criticised from the standpoint of the alternative view that underlying technological opportunities are a more important determinant of the rate of innovation (Geroski, 1990).

THE IMPLICATIONS FOR THE INTERNATIONAL LOCATION OF TECHNOLOGICAL ACTIVITY

THE THEORY OF TECHNOLOGICAL COMPETENCE implies that MNEs will locate research facilities linked to the more sophisticated types of research-related production in countries with similar fields of competence. This is due to the location specificity of technological activity and the difficulty of transferring the most complex elements of a technology (and the systems developed to support it) between locations, because of local interrelatedness. To gain full access to a complementary stream of innovations the firm requires a direct local presence, through a combination of research (necessary for learning in large MNEs) and related skills and routines in production. By this means it is better able to integrate its own unique technological characteristics with local systems, and more effectively to transfer the fruits of this combination to other parts of its international network. The local presence may be achieved through acquisition where the acquired firm is sufficiently technologically related and thus feasible to integrate.

Of course, MNEs also establish less sophisticated assembly types of production elsewhere, and carry out acquisitions for reasons other than the enhancement of technological competence. However, the growth of the firm as a whole depends on the more technologically advanced competence-building parts of its network. Since assembly plants need not be accompanied by local research facilities, in what follows a local research presence is sometimes used as a shorthand for the more technologically sophisticated part of a firm's network. Where research is found elsewhere, it is normally for product adaptation for local markets with fewer implications for production skills and routines.

The extent to which affiliates contribute a specialized field of technological competence to their MNE network depends upon the scope for the international integration of economic activity in an industry. This is influenced by the significance of national regulations, defence contracts, and other such political and social imperatives, the role of which varies across industries (Doz, 1986). In sectors such as aircraft and to a lesser degree pharmaceuticals, the prominent role of government controlled customers places pressure on each affiliate to be nationally responsive rather than to fulfill a specialized function in an internationally integrated network. Subject to such political constraints, from an economic viewpoint integration is facilitated the greater are the economies of scale in different stages of production, the diversity of types of production and the concentration of channels of distribution; and the lesser are the national differentiation of final products and the share of transport and communication costs in total value added (Cantwell, 1990c).

Where production for regional or world markets becomes internationally specialized in accordance with the conditions for production in each location, the scope for a distinctive technological learning process in different countries is increased. The greater the national differentiation of process development, and the greater the extent of technological opportunities in the sector, the greater the technological imperatives toward integration, due to the scope for stronger potential gains from diverse experience. Where international integration is economically advantageous and politically feasible (due to a lack of regulatory constraints), the technological competence theory predicts the growth of intra-industry production between the major centres of innovation for the industry. The objective of the firms involved is to establish their strategies for technological development at an international level.

Evidence in favour of this view can be found in the sectoral pattern of intra-industry production between the United States and Germany, whose firms have been involved in technological competition with one another over a series of industries. American firms have been especially attracted to locate production in Germany in sectors in which German technological activity is comparatively advantaged, while German firms have been similarly disposed to set up U.S. production in those fields in which American technological capability is strongest (Cantwell, 1989). This suggests that the affiliates concerned have a role in technology creation through the adaptation of the skills, routines and search behaviour of the firm in response to and in order to exploit the distinctive opportunities of the local environment.

To take advantage of a local technological competence a firm must locate its own research and allied production facilities there. This is necessary because technology is not reducible to codifiable information or blueprints but, as argued above, is specific to the context in which it is created. A local base facilitates the imitation of the tacit part of the technology in operation in other firms in that location, emulating their learning processes in the local institutional and other environment. Moreover, in a centre of excellence there are spillover benefits or agglomeration economies due to the local presence of the innovative activities of other major technologically related firms. Of course, this does not mean that a firm not producing locally can gain nothing from technological advances in the country in question. The codifiable aspects of the technology that is created may become public and, where they do not, the firm may learn of them through other intelligence gathering operations. It can then attempt to imitate the technology, suitably adapted to its own profile of skills and routines and the conditions of the country in which its own efforts are based. However, the cost of such foreign imitation, and hence its ability to succeed, depends upon the degree of similarity between the locations in question. The more dissimilar countries are in terms of the composition of their technological activity and institutional contexts, the more costly it is to imitate abroad without a local presence. The extent of similarity between locations or firms can be assessed through comparisons of the sectoral distribution of their technological activity, as captured by the patent-based measures described earlier.

Apart from the degree of similarity between locations, the ease of foreign imitation is governed by the structure of technological interrelatedness in any sector. The more closely firms depend upon the complementary efforts of other firms, on network externalities and on their links with other local institutions, the more locationally differentiated that technological activity becomes and the more difficult it is to transfer between locations. A special case of this is the instance of user-producer interaction, by which the user of a technological input such as a piece of machinery feeds back the results of its learning-by-using experience to the producer to encourage appropriate adaptation and the provision of supporting systems. The producers of such technological inputs may be compelled to disperse their research and production base in order to service their international customers. Note that although this appears to the individual firm as a demand side motive for setting up foreign research facilities (related to local product adaptation), at an industry- or economy-wide level it is another result of the supply side differences in the conditions of technology creation and use in alternative locations.

The foregoing suggests that the more important a sector is as a source of technological inputs to other firms, the more MNEs are obliged to establish research in centres where the major users are found, since in each of these locations there is a distinctive structure of interrelatedness between firms. The implication is that international production tends to be higher relative to international trade. It has been shown that for the largest European countries the ratio of intra-industry production to intra-industry trade across sectors varies positively and significantly with an index of net technology creation (Cantwell, 1989). The index of innovation creation relative to use was derived from a technology input-output matrix. Where firms are required to establish close linkages with others in a local network designed to foster technological development in a given location, then each of the leading MNEs in the industry attempts to disperse its production more widely across the main sites of innovative activity.

The existence of network externalities in a location may lead to the establishment of a centre of excellence, to which research related production is drawn and which therefore grows rapidly. Each firm or research facility gains spillover benefits from the local presence of others. These spillovers are a function of technological interrelatedness whereby, as a branch of industrial research becomes properly established in a location, a supporting infrastructure of complementary technologies becomes better developed. In addition, firms in a common vicinity, each employing personnel from similar backgrounds who have contact with one another, enjoy a greater scope for entering into mutual agreements and exchanging information. The codifiable elements of technological spinoffs, which are a by-product of the firm's principal line of technological development and which lie outside its core strategic advantage, may be traded with other firms to which they have a greater relevance. The existence of spillovers and spinoffs lowers the costs and increases the benefits of locating research in a major centre. However, while there may be more skilled labour and scientific personnel in a research centre than in other locations, the supply of skilled workers is still constrained, especially in the short term. When a centre is subject to rapid growth the costs of employing those with the critical skills rises. Moreover, the very existence of spillover effects may pose an adverse selection problem in that a multinational that enjoys a substantial technological lead over its major rivals may believe that it has more to lose than to gain, and accordingly stay out. This decision is again likely to rest mainly on the degree of similarity between locations. Where the composition of technological activity is similar to that of another centre in which the MNE is already established, and the psychic distance between the two is low (in terms of business practices, local customs, language and so forth), then it is less likely to favour a local presence if it has not had one traditionally.

In centres in which the pattern of technological specialization is more clearly differentiated from others, leading MNEs are more inclined to set up local research facilities. Given these strongly differentiated characteristics of technology (which cannot be easily imitated by outsiders) in such a location, competition between firms and the distribution of spillover benefits is more evenly balanced. This also implies that MNEs, which have a narrower range of technological specialization open to them in their home centre, have a greater incentive to locate research facilities in foreign centres to develop the related skills they require. This helps to explain why firms from smaller developed countries such as Sweden, Switzerland, Belgium or the Netherlands have a greater propensity to rely on foreign research (Patel and Pavitt, 1989; Cantwell and Hodson, 1990).

The evidence suggests that between 1963 and 1986 there was a weak tendency towards the international agglomeration of technological activity in roughly three quarters of all sectors (Cantwell, 1990d). The effect of agglomeration economies and local spillovers has been partially offset by competition for skilled labour and other resources in the main centres for any industry, the decision of certain MNEs to stay out of some more closely related centres, and the difficulties confronting international economic integration in a number of sectors. In any case, it seems that the internationalization of technological activity is only part of a broader explanation of this locational concentration. A strong form of the international agglomeration of technological activity, in which the initially best established centres clearly consolidated their position, was observed for approximately one-third of all sectors. The most important constraint on the continuation of such agglomeration in the longer term is the changes in leadership which occur with shifts in the prevailing technological paradigm. In this case established centres may be locked in to fields of technological development which have run their course and now offer few new opportunities. At this stage the local structure of interrelatedness provides external diseconomies, and makes it costly to switch to new lines of activity.

THE IMPLICATIONS OF THE THEORY FOR THE IMPACT OF MULTINATIONALS ON LOCAL DEVELOPMENT

THE THEORY OF TECHNOLOGICAL COMPETENCE implies that host-country benefits depend upon having the domestic competence to attract spillover generating activities and to appropriate the spillovers. Given that technology is location- as well as firm-specific, the degree of technological competence varies between countries just as it does between firms. Broadly speaking, in the industrialized countries three stylised cases can be distinguished. First, where local industry has a high technological capability, foreign MNEs are more disposed to set up research facilities, and by so doing they provide a further helpful competitive stimulus to the innovation of local firms. Second, where indigenous firms are very weak, the entry of foreign MNEs may help them to upgrade their production even though the local establishment of fundamental research and development is unlikely. Third, in the intermediate case in which indigenous firms have active research programmes but are not at the technological frontier, their position may be undermined by the local expansion of foreign firms relying principally upon research carried out elsewhere.

Citing the motor vehicle industry in Europe by way of illustration, between the 1960s and 1980s American MNEs had a favourable impact in Germany, where local technological competence was strong, and in Belgium and Spain, where it was weak. By contrast, in the 1960s Britain was a location of intermediate or middle ranking technological competence, but she lost out badly to greater regional competition and the restructuring of the operations of American MNEs in Europe (Cantwell, 1987). While the German share of motor vehicle patents granted in the United States, and attributable to inventions in the largest European countries, rose from 43 percent in 1963-69 to 58 percent in 1977-83, the United Kingdom share fell from 29 percent to 19 percent over the same period.

At one extreme (strength), in a centre of excellence in motor vehicles such as Germany, foreign MNEs have an incentive to set up fundamental research in order to gain access to a complementary stream of technological development. They require a local research presence to learn those aspects of a technology which are specific to local circumstances, in accordance with domestic scientific and educational traditions and business practices. In doing so they contribute directly to the strength and diversity of local technological competence, and indirectly through the impetus they provide to the local innovative activity of indigenous (and other foreign) firms by increasing technological competition.

At the other extreme (weakness), employment, if nothing else, may grow from foreign MNEs setting up assembly plants. This has been the experience in Belgium and Spain, and is now beginning in the United Kingdom, which no longer has a general competence in motor vehicle technology but has been reduced to more limited specialization. It is possible that the gains of an initially weak location may go beyond this, for two reasons. First, final product (vehicle) assemblers may be followed by innovative component manufacturers, reestablishing the same contractual network relationship they enjoy elsewhere. Paradoxically, this may happen in part due to political pressure for local content requirements in competing locations in the same region. Second, through joint ventures and strategic alliances local firms may improve their capabilities. This possibility is enhanced if the expansion of foreign MNEs is sustained, and if what begins as an assembly outpost for them becomes a regional centre as they draw one another in.

In the intermediate case, the moderate strength of the research and technologically sophisticated skills and routines of indigenous producers may depend on a protected local market. The local presence of the most internationally competitive MNEs is likely to damage their position, obliging them to switch to simpler types of production. Foreign MNEs are unlikely to establish fundamental research facilities unless the local field of technological strength is highly distinctive. Otherwise they may restrict their local basic research activities to a few specialized joint ventures. Subsidies to research may be ineffective where they lead only to more applied research rather than technologically sophisticated production, as has been witnessed in the pharmaceuticals sector in France (Burstall and Dunning, 1985). However, the ability of foreign MNEs to capture market share through the competence they derive from their other regional and international operations may reduce the scale and downgrade the quality of indigenous research. There was a continuous deterioration in the technological base of British motor vehicle production between the early 1960s and mid 1980s; even the absolute value of research spending fell. Associated with this, the British share of the number of passenger cars produced in the largest European countries fell from 26 percent in 1960 to nine percent in 1982. During the same period, British exports dropped by a similar proportion and a substantial trade deficit developed (Cantwell, 1987). This suggests that there is a limited scope for government policies to encourage local technological development through inducements to foreign firms. In a field in which the local economy is clearly competent to assimilate spillovers from foreign MNEs it is also an attractive location for them. If an economy lacks competence in an area, foreign MNEs are reluctant to invest in local research facilities. Where they do, as in the pharmaceutical sector, for example,because some governments impose the requirement of a local research input as a condition for the purchase of goods, the research work undertaken is likely to be applied rather than basic. It is unlikely to become part of an international strategy, providing technological inputs to other parts of the firm. The potential for host-country benefits is further constrained by the lack of ability in indigenous firms to appropriate any spillovers.

However, in the intermediate case government policies to sustain a local technological capability may well have a role, and indeed it may be very damaging for a national economy if a government leaves the outcome entirely to the market. Left entirely to market forces technological activity tends to polarize in just a few locations. The impact of such a locational polarization of sophisticated capability may be especially significant in the case of a key sector which provides core technologies used in other sectors, or is highly integrated with the remainder of the economy in other ways. In the British motor vehicle industry, for example, the decline of one sector spilled over into a much more widespread contraction of manufacturing production. The question in such cases is to decide which intermediate sectors should be candidates for managed decline and which should be targets for an expansion of technological development.

One answer to this question can be found in an assessment of the Japanese experience. Among the sectors in which a host country has some competence but is not dominant, technological opportunities rise faster in some industries than in others. This is partly conditioned by the overall technological paradigm, but also by the local relationship between the areas of traditional strength. Given that technological change is incremental, there tends to be a move toward fields of activity which are becoming more closely related to the existing areas of leadership, and a decline of others. As an objective such incremental change may aim at an upgrading of the research intensity of production by shifting from the simpler to the more sophisticated. It may thus be possible to distinguish between "sunrise" and "sunset" sectors. It is feasible to promote local technological activity successfully in the former group, consistent with the market led course of host-country development (in the absence of intervention).

Of course, in the Japanese example foreign MNEs were not until recently encouraged to establish local research and production directly. Instead, the selective licensing of foreign technologies in target areas was planned and, to some extent, centrally organized (Ozawa, 1987). This strategy was largely due to the fact that in the early post-war period Japan lay some way behind the technological frontier, and so had to nurture its areas of potential development carefully. For the same reason foreign MNEs may have been unwilling to establish local research at this stage. Establishing the tacit element of technology proved to be very expensive, not least because of the major differences between Japanese and Western production systems. Once the process was under way, however, this became a source of independent technological development. The policy worked because of the intense domestic competition between Japanese firms, which ensured the same kind of spillover benefits that might otherwise be associated with foreign entry into a field in which indigenous technological effort is already notable. Local efforts towards upgrading were concentrated in areas of comparative technological advantage, in electrical and related engineering products. This led, for instance, to a shift from basic electrical goods to electronics, and from shipbuilding and heavy engineering to motor vehicles and consumer durables (Ozawa, 1990), each associated with related but more sophisticated types of technological activity. South Korea has recently followed a similar development path, in turn licensing Japanese technology.

In Western Europe and most other industrialized countries, a similar effect may well depend upon a direct foreign presence. This is suggested by the post-war experience in which the entry of American firms disturbed a series of cartel-like agreements between European producers, and provided the catalyst for a new wave of technological competition (Cantwell, 1989). The effects then varied across industries and countries essentially in the way predicted by the theory of technological competence. Where there was a tradition of local technological capability, the impact tended to be favourable and indigenous research facilities were extended. However, where competence was greater elsewhere in Europe, the combination of MNEs being more drawn to these alternative centres and greater competition between locations due to regional integration may have been detrimental. In some of these cases, namely in fields becoming more closely related to the main areas of domestic technological competence, governments may have been able to promote a different course.

THE RELEVANCE AND POLICY IMPLICATIONS OF INTERNATIONAL TECHNOLOGICAL DEVELOPMENT

THE THEORY OF TECHNOLOGICAL COMPETENCE implies that, depending on the number of countries in which competence resides, technology flows will be multilateral. Depending also upon the scope for the international integration of economic activity, MNEs will refine their internal division of labour.

This may lead to a greater concentration of technological activity than of production, as research-related production is drawn to centres of excellence and locationally separated from assembly. However, the composition of technological activity may become more specialized in each of the major centres in which it is conducted. At the very least it will have location-specific characteristics and require a distinctive adaptation of the skills and routines of the firm.

The prediction of the theory of technological competence that international technological development is dispersed across several major centres, each with its own specialized areas of competence, can be contrasted with the product cycle model, in which technology is diffused outwards from a single central location (Vernon, 1966, 1979). The product cycle model represents a conventional depiction of international technology flows, which are seen as running in a single independent sequence from creation (in one location) through transfer to a firm or affiliate (in another location) to diffusion to a wider variety of firms in the host country. The theory of technological competence proposes, instead, that the role of an affiliate is not only to implement the main capabilities of the firm in another location but also to act as a source for new technological development through its links with other host country firms and institutions. The result may be a system of intra-industry technological activity between the leading firms of the main centres. (For a further discussion of this alternative to the product cycle model see Cantwell, 1989.)

The barriers that inhibit cross-border integration are the major constraint on the emergence of this kind of international specialization of technological activity. In industries such as aircraft, telecommunications and pharmaceuticals there is pressure on affiliates to be nationally responsive and to gear their research to adapting their final products to changing local market requirements. This limits their ability to initiate projects which would fully exploit local research potential and fit the requirements for complementary technological inputs in the parent company or other affiliates. In this situation the simpler types of technological activity are likely to be more widely internationally dispersed with production, and there may be little interaction between research facilities. It is possible that only applied development work becomes internationally dispersed, with basic research being concentrated at home.

The barriers to international integration that remain in some sectors have prevented the reorganization of technological activity by MNEs. It should also be noted that such a reorganization does not necessarily imply an increased internationalization of technological activity. What it does entail is a changed geographical structure of research, and an increased differentiation of activity in the principal locations. It is possible, though, that a dispersal of basic and allied research to the major centres may be offset by a reduction in the local support facilities available in other locations, at a time when the centrally funded resources of the firm devoted to basic technological development are rising in response to greater international competition. In this event the expansion of technological activity in selected centres is simply part of the rationalization of the overall network of international research in the firm. The countries most favoured may vary for different firms, even in the same industry, given that they have their own specific fields of specialization.

Although the investigation of the patterns of geographical and sectoral specialization of technological activity at a company level is still at an early stage, there is enough evidence to suggest that this is a useful line of enquiry. The conventional view that research and development tends to be heavily concentrated in the home country, as encapsulated in the product cycle model, seems to have relied mainly on data from American firms. For some time, European and Canadian firms have made much greater use of international research strategies than have their counterparts from the United States and Japan (Cantwell and Hodson, 1990). More recently, however, it appears that American MNEs have also begun to appreciate the benefits of a wider dispersion of technological activity, and have increasingly made use of foreign research facilities. Generally, the foreign research undertaken by the world's largest firms has been especially attracted to the main centres of excellence for their primary sector of activity, although this does not hold true in industries such as aircraft manufacturing in which the scope for integrating facilities internationally is limited.

A related trend is that countries have tended to become more narrowly specialized in their technological activity, concentrating more in the fields in which they enjoy the greatest local competence. This is consistent with companies specializing in each location in accordance with local potential and the best opportunities for spillovers between firms active in related areas. Between the early 1960s and early 1980s, 11 out of the 16 major industrialized countries experienced an increase in their degree of technological specialization (Cantwell, 1989). The main exception is Japan where, owing to a much faster overall rate of innovation, the structure of technological activity became more dispersed, especially early in the period. At the same time, there is evidence to suggest that individual firms have tended to broaden their technological base, often to support a narrower range of final products which constitute their core business. Innovation in the main field depends upon complementary technologies in related areas, and the uncertainty over which types of technological search will yield the greatest rewards also leads to a greater sectoral dispersion. For these reasons, the technological diversification of firms tends to be greater than their degree of output diversification (Pavitt, Robson and Townsend, 1987b).

The implication of all this is that at least with respect to the research carried out by firms operating in internationally integrated industries, some countries may have to accept a more restricted span of technological activity. Their greatest success is likely to be in attracting research in their fields of traditional strength, but the types of technological activity most favoured are also those that are more closely related to others in the same location. If this means simply a refinement of the international division of labour in research, then governments may be encouraged to promote such specialization. For example, if a local textiles manufacturer concentrates its research on an important kind of textile machinery abroad, this may enhance its domestic research on synthetic fibres to a point that more than compensates for its local loss of expertise in mechanical technology, owing to a local comparative advantage in chemicals-related technology. However, the extent to which such specialization proves to be acceptable to national governments depends on two considerations.

First, smaller countries are more likely to find greater specialization acceptable than larger countries. Large countries benefit from a presence in all the major sectors responsible for core technologies that provide technological inputs for most other parts of the economy. The establishment of local networks of user-producer interaction ensures that such technologies can thereby be developed in the form required for the specific context of the location in question. In the case of an economically integrated region such as the European Community, this suggests a role for technology policy at an EC level, to ensure that the direction of specialization in different member states is complementary.

Second, the local impact of specialization may be adverse if the sectors of technological activity which are allowed to run down are the providers of core inputs to the wider economy, or even just to the branches chosen for expansion. In other words, it is not enough to look only at the local pattern of comparative advantage in innovation; the structure of local interrelatedness between sectors must also be considered. Governments may also wish to pay special attention to promoting areas of technological activity significant to industries that account for a large share of local production or that are vertically linked to other such industries. This might still be consistent with permitting a greater specialization of research in the relevant fields.

Overall, while international technological development within the firm is a consequence of the combination of the specific characteristics of technology in different firms and different locations, the distinctive competences of firms and countries are likely to be reinforced by it. MNEs that are able to integrate research activities internationally increase their technological competence, although this may also be associated with a greater diversity of related technological activity. In contrast, countries are liable to become more technologically specialized, although governments may have some effect on the precise composition of such specialization. A central issue in determining which firms or countries benefit from the course they have become locked in to is the variation in the growth of technological opportunities across sectors, and the nature of interrelatedness between different types of technological activity. While some suggestions on these themes have been advanced here, they clearly warrant further attention.

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DISCUSSANT'S COMMENT

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JOHN CANTWELL HAS UNDERTAKEN a large task in this paper — which develops the theory of technological competence, applies it to international corporate research strategies, and derives some implications for public policy. I will make a brief comment on the theory, then look at some of the public policy issues.

The issue posed is what determines international competitiveness and why some firms in a global industry grow faster than others. Technological innovation viewed as an evolutionary, cumulative and differentiated process is considered to be a key to these questions. "The basic tenet is that technology is partialy tacit, is specific to the context in which it has been created, or adapted (the firm and the location) and is dependent upon the learning and skill of those that have developed and operate it. Technology is a product of a steady search for improvements and a learning process in a particular firm". Many propositions follow from this, as Cantwell notes. Some are that the skills and routines involved cannot be fully communicated to others unless they join the firm's team and undergo the same learning process that the leading firm places a higher valuation on its own specific technology than would a rival; that firms become locked into a particular path of innovation, shifting only gradually to others; and that international technological leadership changes infrequently, in response to changes in the dominant cluster of rapidly growing technological opportunities.

It is important to note that the direction and rate of innovation by firms depends on the growth of technological opportunities, which depends on the dominant cluster of innovations.

The first question is how broadly one believes the theory to apply. Increased technological capability reduces unit costs, improves product quality or range, hence raises profit margins — results which suggest a wide application. In fact, Cantwell explicitly excludes a considerable range of less measurable factors which can affect the competitiveness of firms. These other factors explicitly include the organizational capabilities of the firm and the entrepreneurial ability of its managers, but extend presumably to such skills as marketing and finance which are not developed in the paper (see, for example, Porter, 1990, ch. 2). The services sector, where the most rapid growth in foreign direct investment has occurred in the 1980s, does not fit well into this framework, since these organizational and marketing skills seem to be far more important in such sectors than the research and development focus which dominates the second half of the paper. The measures of technological competence, using patent data, confirm this impression. Finally, for most of the paper it is the world's largest firms which dominate the international analysis. Thus the technological competence theory as developed in this paper appears to apply to the largest international manufacturing and, perhaps, raw materials firms.

It should be clear that the technological competence theory as presented here deals with a narrower range of factors than the eclectic theory by Dunning and other similar approaches to multinational companies. It also brings a more convincing perspective to some of the central questions about international firm strategies. One of these is the prediction about the international location of R&D and related functions. Most of the earlier studies assumed such R&D would remain heavily concentrated in the parent firm. This appears to have been based on American experiences where less than five percent of the multinational firms' R&D was in subsidiaries abroad in the early 1970s — a figure which has risen substantially since. Cantwell notes that very large parts of the R&D of multinationals from smaller countries was placed abroad. In fact, if one interprets knowledge to be something broader than R&D, United Kingdom multinationals in the late 1960s were receiving a significant return from knowledge sharing with affiliates (Reddaway et al, 1968, ch. 25-26).

What emerges from this theory is a picture of multinational firms internalizing the R&D which is central to them in strategic terms, such as core technologies. They will also locate R&D in countries with similar areas of technological competence in order to have the localized capacity needed to tap into specialized research. Technology flows will be multilateral, reflecting some international division of labour in technological activity which could be more concentrated than that in production and assembly. There are two major policy outcomes of this model for a country such as Canada. First, there appears to be limited scope for inducements to foreign firms to spur local technological development. Such inducements will work best where the country already has significant strengths — this necessarily follows from the evolutionary, cumulative character of the technological competence process as noted above. Countries that are not already centres of excellence on a broad front are at a disadvantage, unless technological opportunities now cluster in a way to benefit them and they are ready to take advantage of these.

Second, what about the impact of foreign multinationals on the research of local firms? Cantwell's view on what the theory of technological competence suggests, is that foreign multinationals can provide a competitive stimulus where local technological capabilities are high, and help local firms upgrade their capabilities when they are low — beneficial effects in both cases — but can have negative effects when such capabilities are intermediate. The argument in the intermediate case is that the foreign multinationals' ability to capture market share, especially if local firms are protected and not internationally competitive, will reduce the scale and quality of local research. One should note this is not a traditional infant industry argument but one directed at a mature industry which, for whatever reasons, has not become internationally competitive.

I have difficulty in following this intermediate case for two reasons. One is the example chosen. Cantwell notes that the advent of American automobile multinationals had a favourable impact in Germany, which had a strong technology in this area, and in Belgium and Spain, which were weak in this sector. Britain is described as having intermediate technological competence, and it certainly lost market and export share. Before accepting the conclusion reached regarding the role of technological competence in these outcomes, one would have to demonstrate that the other determinants of competitiveness noted above were less significant. One would also have to demonstrate that the decline in automobiles was not part of a general industrial decline vis à vis Germany and Spain in particular, reflecting a broader set of macro and micro variables.

If one grants Cantwell's point, the requirements for a successful policy are demanding. It would be necessary to limit or deny entry by foreign multinationals and also limit imports in order to prevent the loss of market share and thus of research capacity. Governments do this, of course, but usually in half-hearted ways as they balance different needs — for example, allow the multinationals to enter but handicap them in various ways such as limiting access to government procurement. Cantwell points to Japan's post-war experience as one answer — a high degree of import protection, very limited access by foreign multinationals, extensive licensing, sharp domestic competition, and a gradual and partly managed shift to newer sectors. I agree with his judgement that the key question is which intermediate sectors should be allowed and assisted to decline and which to expand, but distinguishing these analytically and implementing the required policies systematically appear to demand a set of characteristics few other countities possess.

Let me touch on two other issues. Canada has an important set of natural resource and processing sectors where conventionally measured R&D is low partly because it gets buried in the production process but partly, also, because their advantages lie elsewhere, for example, in managerial expertise with regard to natural resource development and marketing. Most of Canada's major multinationals are represented by such firms (Rugman, 1987, ch. 3). These seem to me to fit only in part the model of technological competence, unless it is extended to encompass knowledge intensity more broadly and not just conventional R&D and technological innovation. The second point relates to the issue of takeovers of firms by foreign or domestic multinationals. The technological competence model, as discussed here, seems to rely on new direct investment. The reaction to a leading firm is imitation. There is scope for cooperative activities between specialized firms but, by the very nature of the theory, a technology is worth more to the originator than to other firms. Yet, the observable fact is that a very large part of the value of direct foreign investment is by takeovers of rival firms. One can explain this, again, by appealing to other factors not in the model, such as marketing complementarities. Or one can note that, if we stick with a technological competence theory, many of the purchasers who wander beyond their core or closely complementary technologies in such purchases, are going to regret it. There is some evidence for this latter view in studies of the effects of mergers and acquisitions on rates of return and other company objectives. In a general theory of competitiveness and growth of the firm some attention to this phenomenon seems warranted.

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3

The Limited Importance of Large Firms in Canadian Technological Activities

INTRODUCTION

THE LEVELS AND SECTORAL PATTERNS of technological activities in Canada are often criticized as being inadequate and unsatisfactory because of three factors: Canada's proximity to a large and technologically more powerful neighbour; its undue dependence on indigenous natural resources; and foreign direct investment (Science Council of Canada, 1981). Other analysts dismiss these claims, arguing that the geographical proximity and economic interdependence of the two countries promote the quick and cheap diffusion of American technology and ensure Canada's high living standard.

Geographical proximity and economic interdependence are not sufficient in themselves for an efficient diffusion of technology. Many studies, including one published by the Economic Council of Canada (de Melto et al, 1980) show that successful imitators commit substantial resources to the technological and related activities necessary for learning, adapting and improving. In any case, there is no reason why Canada's situation should *automatically* result in a relatively low level of technological activity. Sweden and Switzerland are among the most technological-intensive countries in the world, despite (because of?) their smallness and proximity to technologically powerful Germany. The newly constituted democratic countries of Central Europe are also eager to become part of the greater German technological sphere. There is also the example of Sweden, which has broadened its technological base over time from technologies related to the exploitation of natural resources to include most sophisticated machinery.

Meanwhile, a vigourous and inconclusive debate continues in Canada about the effects of a high proportion of foreign direct investment (FDI) on the emergence of strong technological activities. Given such a setting, the importance of large firms in national systems of innovation can be easily exaggerated and we contend that this is especially the case in Canada.

First we describe the composition and limitations of our data base. Next, we show that American patent statistics attribute a smaller proportion of the world's technological activities to large firms than R&D statistics would have us believe. The next section points out that although the technological activities of large firms in Canada are indeed closely linked to those in the United States, their relative importance in the national total is smaller than in all the other major OECD countries. We conclude that exclusive concentration on large firms and R&D activities overlooks the considerable strengths of other (small and medium-sized) Canadian firms in technologies with strong upstream and downstream linkages with abundant natural resources.

THE DATA SET, ITS ADVANTAGES AND LIMITATIONS

COMPILATION AND COMPOSITION

THE DATA SET HAS BEEN COMPILED from information provided by the U.S. Patent Office and includes the name of the company, the technical sector, and the country of origin of each patent granted in the United States from 1969 to 1986. One difficulty with this source is that the U.S. Patent Office grants patents only in the name of the applicant. Consequently many patents are registered in the names of subsidiaries and divisions of companies that are different from those of their parent companies.

At present, tracing patents and consolidating patent ownership under the name(s) of parent companies can only be accomplished manually, drawing on publications like "Who Owns Whom". Our earlier consolidations for the United Kingdom and the Federal Republic of Germany (Patel and Pavitt, 1989) have recently been expanded and now include 686 of the world's largest firms. With the help of the Economics Department at the University of Reading, we have also included in our data set the following information on each firm: country of origin; sales; employment; and R&D expenditures for years 1972, 1977, 1982 and 1984. The last two variables are not available for all the firms for each of the years.

Table 1 shows the top 20 firms that were granted patents in the United States from 1981 to 1986, showing total patents according to our own consolidated classification, and the original number as reported by the U.S. Patent Office. The table shows that some firms have similar totals under both classifications; notably General Electric (U.S.), Hitachi, IBM, Toshiba, RCA, Canon, Westinghouse, Dow, Nissan and Mobil. However, other firms have considerably more patents in our consolidated classification, and consequently higher rankings: specifically, Bayer, Siemens, Philips, AT&T, Du Pont, Hoechst, Allied, Matsushita and United Technologies. The lowest level of annual sales in 1984 for the companies listed was about $900 million.

Table 2 shows the distribution of the 686 large firms in our data base, according to their home country and to their principal sector of activity.

TABLE 1

Top 20 Patenting Firms in the U.S. (1981-86): Patel and Pavitt list versus the U.S. Patent Office List

COMPANY NAME	PATEL AND PAVITT	U.S. PATENT OFFICE
General Electric Company (US)	4587	4527
Hitachi	3710	3416
Bayer	3352	2304
IBM	3207	3207
Siemens	3151	2480
Toshiba	3094	2855
Philips Corporation	2968	2464
AT & T	2732	1980
RCA	2716	2716
E. I. Du Pont	2401	1971
Hoechst	2270	1327
Canon	2266	2266
Westinghouse	2145	2090
Ciba-Geigy	1992	1709
Allied Corporation	1989	1085
Dow Chemical Company	1961	1816
Nissan	1960	1887
Mobil Oil	1907	1749
Matsushita	1895	1276
United Technologies	1889	1028

NOTE: In the Patel and Pavitt classification, firms are ranked in order by the total number of patents granted.

Slightly less than half the total number of firms are American-owned, about one-fifth are Japanese and nearly one-third are European. The United Kingdom is the largest European contributor, followed by the Federal Republic of Germany and then France. In terms of the industrial distribution, firms whose principal activities are related to mechanical engineering and metal manufacture account for 21 percent of the sample. Those in chemicals and pharmaceuticals account for 16 percent, while those in electrical, electronic and computing machinery account for 12 percent.

ADVANTAGES AND DISADVANTAGES

PATENT STATISTICS have often been used by economists and others as proxy measures of technological activities.[1] Their general advantages, compared to other measures such as R&D expenditures, are: with the advent of modern information technology, they are readily available over long time periods; they can be broken down in great statistical detail, according to firm, technical field

TABLE 2

THE DISTRIBUTION OF THE 686 LARGE FIRMS IN THE SAMPLE BY PRINCIPAL ACTIVITY AND COUNTRY

	US	JP	CA	UK	GE	FR	SE	CH	NL	IT	BE	NO	FI	OT	TOTAL
Chemicals	35	25	-	2	5	5	-	1	2	2	1	1	-	1(AU)	80
Pharmaceuticals	18	4	-	3	2	-	-	2	-	-	-	-	-	-	29
Mining (Coal & Oil etc)	29	10	3	5	4	2	-	-	1	1	1	1	1	-	58
Textiles, Cloth. & Leather	12	5	-	2	1	1	-	-	-	-	-	-	-	-	21
Rubber and Plastics	6	3	1	1	1	1	-	-	-	1	-	-	-	-	14
Paper & Wood products	21	6	4	1	1	-	4	-	-	-	-	-	2	1(IE)	40
Food	33	15	2	14	-	4	1	2	1	-	-	-	-	-	72
Drink and Tobacco	8	1	4	8	-	-	-	-	1	-	-	-	-	1(AU)	23
Non-metallic Minerals	11	6	1	6	-	2	-	1	-	-	-	-	1	-	28
Metal Manufacture	22	13	6	2	13	4	1	1	1	1	2	1	-	1(AU)	68
Mechanical Engineering	37	12	2	9	6	1	4	2	2	-	-	-	2	-	77
Electrical/Electronics	31	18	1	4	4	2	3	1	1	1	-	-	-	-	66
Computing Machinery	12	2	-	1	1	1	-	-	-	1	-	-	-	-	18
Instruments	10	6	-	-	1	-	-	-	1	-	-	-	-	-	18
Motor Vehicles	12	19	-	3	6	3	2	-	-	1	-	-	-	1(ES)	47
Aircraft	14	-	-	2	1	4	-	-	-	-	-	-	-	-	21
Other Transport	3	1	-	1	-	-	-	-	-	-	-	-	1	-	6
Total	314	146	24	64	46	30	15	10	10	8	4	3	7	5	686

NOTES:

1. Country Abbreviations

US = United States
JP = Japan
CA = Canada
UK = United Kingdom
GE = FR Germany
FR = France
SE = Sweden
CH = Switzerland
NL = Netherlands
IT = Italy
BE = Belgium
NO = Norway
FI = Finland
OT = Others: AU = Austria; IE = Ireland; ES = Spain.

2. The home country is not easily identifiable in two notable cases: Shell, which we classify as Dutch, and Unilever which we classify as British.

and geographical location; and they capture technological activities undertaken outside R&D departments, such as design activities in small firms and production engineering in large firms. Their main disadvantage is that, like other routine measures of technological activities, they do not satisfactorily measure a major field of technological growth — software. These advantages and disadvantages specific to our data base are along three dimensions: the nature of the technological activities measured, variations in the propensity to patent, and the interpretation of trends over time.

Nature of the Technological Activities Measured

Since a patent is normally granted in recognition of a technical novelty, our data are better able to capture technology creation than technology diffusion-transfer-imitation. However, given the nature of technology,[2] the distinction between these two sets of activities cannot be rigid. For the diffusion-transfer-imitation of technology generally requires technological activities by the imitator, which sometimes results in improvements over the original.[3] Patenting reflects such imitation, which is typical of companies competing close to the world's technological frontier in advanced countries. However, patenting does not reflect some other types of imitation and related technological activities which do not involve originality, such as trade in capital goods and know-how, on-the-job training, assimilative R&D and production engineering, and the foreign education of scientists and engineers. These are particularly important forms of imitation for developing countries (see Rosenberg and Frischtak, 1985).

Variations in the Propensity to Patent

Patenting is also an imperfect measure of novel technological activity. Its primary function is to act as a legal barrier against imitation. It should be borne in mind that there are three kinds of variation in the propensity to patent the results of tehcnological activities.

First, there are variations among countries. These reflect differences in the costs (e.g fees) and benefits (e.g. degree of protection, potential market size) of patenting. Patenting in the United States is a reliable standard of measurement since screening procedures are homogeneous and rigorous, and a successful patent provides relatively strong protection in a large market. Thus, a recent survey of patenting behaviour of multinational firms shows that the United States is the first foreign country in which they normally seek patent protection (Bertin and Wyatt, 1988). For this reason, the international distribution of the sources of patenting in the United States are highly correlated with the international distribution of business enterprise R&D expenditures, in both aggregate and specific sectors (Soete and Wyatt, 1983; Soete, 1987; Patel and Pavitt, 1987).[4]

Second, there are variations in the propensity to patent among technical fields. These reflect differences in the relative effectiveness of patenting as a means of protection against imitation, compared to other factors such as secrecy, know-how, and first-comer advantages on learning curves.[5] For this reason, it is advisable to use sectoral measures that normalise for the total number of patents in each sector.

Third, there are variations among firms in the propensity to patent. These reflect *ex ante* uncertainties and differing patenting practices over a wide range of patents with relatively low value.[6] Nonetheless, statistically significant correlations have been found between inter-firm differences in R&D in the United States, and U.S. patenting (Soete, 1978; Pakes and Grilliches, 1983).

Interpretation of Time Trends

At present, our compilation of consolidated data for the 686 firms under review is limited to 1984. Our time-trend analyses of patenting by companies between 1969 and 1986, therefore, reflect the firms as they were constituted in 1984. They do not take into account any changes resulting from purchases or sales of divisions before or since then. Thus, the changes measured over time are comprised of those parts of the firm retained up to 1984, together with those acquisitions made up to 1984: in other words, what the firm kept and what it bought, up to 1984.

LARGE FIRMS IN THE PRODUCTION OF THE WORLD'S TECHNOLOGY

TABLE 3 SHOWS, in aggregate, across 33 technical fields, the shares of U.S. patents granted from 1981 to 1986 to the large firms in our sample, to government agencies, to individuals,[7] and to other firms with sales of up to $900m in 1984.

AGGREGATE

IN AGGREGATE, our set of large firms account for just under half the world's technological activities, as measured by patenting in the United States, and for about 60 percent of that undertaken by firms (excluding individuals and government agencies). This distribution confirms what we found in an earlier study of the United Kingdom and the Federal Republic of Germany (Patel and Pavitt, 1989), namely, a lower concentration of technological activities among large firms when measured by U.S. patenting rather than by R&D expenditure. Although strict comparisons at the world level are not possible, national surveys in OECD countries show that typically about 80 percent of R&D activity is concentrated in firms with 10,000 or more employees. Given that the cut-off level of employment at the lower end of our sample is about 8,000 employees, the proportion of total patenting accounted for by our large firms would have to be more than 80 percent to reach the same level of concentration as R&D expenditure.

DIFFERENCES AMONG SECTORS

TABLE 3 ALSO SHOWS MAJOR DIFFERENCES among sectors in the relative importance of large firms and other sources of technological activities at the world level. Government agencies are relatively unimportant in aggregate but account for more than five percent in aircraft, nuclear reactors, and telecommunications — all technologies heavily influenced by military programs. As in our earlier analyses, large firms are relatively important in chemicals (eight sectors with shares between 56 percent and 79 percent), motor vehicles (62 percent), and electrical and elec-

TABLE 3

Sources of U.S. Patenting in 33 Technical Sectors: Percentage Shares in 1981-86

	LARGE FIRMS	GOVERNMENT AGENCIES	PRIVATE INDVIDUALS	OTHER FIRMS
Semiconductors	80.28(138)	3.94	2.69	13.08
Hydrocarbons, mineral oils etc.	79.45(158)	0.82	5.77	13.96
Agricultural chemicals	78.98(92)	0.96	4.29	15.76
Organic chemicals	77.04(348)	1.73	2.71	18.52
Photography and photocopy	73.40(147)	0.39	5.84	20.36
Calculators, computers, etc.	69.23(281)	1.61	7.14	22.03
Inorganic chemicals	67.37(218)	2.81	5.57	24.24
Bleaching dyeing and disinfecting	65.20(125)	1.94	7.75	25.11
Road vehicles and engines	62.45(179)	0.34	20.49	16.72
Electrical devices and systems	59.62(327)	3.26	11.38	25.74
Drugs and bio-affecting agents	59.48(215)	3.35	8.08	29.09
Power plants	58.17(153)	2.48	20.79	18.56
Telecommunications	57.41(289)	6.54	13.69	22.36
Image and sound equipment	57.42(207)	1.80	17.61	23.17
Chemical processes	56.36(503)	2.36	10.91	30.36
Plastic and rubber products	55.58(327)	1.56	14.01	28.84
Metallurgical and other mineral proc.	53.30(372)	1.75	13.94	31.02
Gen. electrical industrial apparatus	50.30(407)	2.17	15.73	31.80
Food & tobacco (proc. and products)	48.96(175)	1.61	15.50	33.92
Non-metallic minerals, glass etc.	48.50(431)	1.24	20.22	30.04
Mining and wells mach. and processes	47.68(178)	0.89	22.47	28.95
Nuclear reactors and systems	47.45(38)	6.83	7.60	38.11
Aircraft	43.05(62)	14.44	23.47	19.04
Instruments and controls	40.93(491)	3.55	22.06	33.46
Gen. non-electrical industrial equip.	39.86(433)	0.97	25.33	33.84
Appar. for chemicals, food, glass etc.	39.76(516)	0.97	21.42	37.85
Metallurgical and metal working equip.	34.99(379)	0.68	27.18	37.16
Assembling & material handling appar.	29.97(377)	0.87	28.85	40.30
Other transport equip. (exc. aircraft)	28.46(197)	1.39	42.01	28.14
Non-electrical specialized machinery	27.63(481)	0.76	30.39	41.22
Miscellaneous metal products	23.35(444)	0.67	40.28	35.70
Other (not elsewhere classified)	13.49(241)	5.25	65.71	15.55
Textile, clothing, leather, wood prod.	13.08(117)	0.71	52.06	34.15
All Sectors	49.10(660)	2.11	19.68	29.10

Notes:

1. Table is sorted by the share of large firms.
2. Each row totals 100, (rounding errors).
3. The number of large firms active in technical sector is in parenthesis.

tronic products (five sectors between 57 percent and 80 percent), but unimportant in capital goods (seven sectors between 23 percent and 40 percent).

Table 4 confirms a significant positive correlation across sectors between our large firms' patenting shares, and the shares of the top 20 technically active firms ranked according to sales. It also confirms a significant negative

TABLE 4

CORRELATION MATRIX OF VARIOUS MEASURES OF CONCENTRATION OF TECHNOLOGICAL ACTIVITIES: 33 SECTORS, 1981-86

	LFIRMS	GOVT.	PIND	OTHF	CRSALE20
Govt.	–0.040				
PInd	–0.909*	–0.008			
OthF	–0.625*	–0.230	0.273		
CRSale20	0.661*	0.266	–0.564*	–0.576*	
HIPPG	0.606*	0.417	–0.524*	–0.573*	0.806*

NOTES:
For each sector:

LFirms = the share of large firms.
Govt = the share of government agencies.
PInd = the share of private individuals firms.
OthF = the share of firms other than the large firms in our sample.
CRSale20 = the share of top 20 technologically active firms sorted according to sales.
HIPPG = Hirfindahl Index calculated as the sum of squared shares of the firms active in each technical sector aggregated according to their Principal Activity.

* = Correlation Coefficient signficantly different from zero at the percent level.

relationship with shares of patenting of "Private Individuals" and shows that the sectoral shares of "Other Firms" (from the very small up to those with $900 million annual sales in 1984) are more similar to those of private individuals than to those of our large firms.

AN EXPLANATION OF INTERSECTORAL DIFFERENCES

RECENT STUDY HAS SHOWN that intersectoral differences in the concentration of technological activities can be best understood in the context of dynamic interactions between technological opportunities and their appropriability on the one hand and the competitive growth of innovative firms, on the other. Briefly stated, higher technological opportunity and appropriability will result in higher concentration (Dasgupta and Stiglitz, 1980; Nelson and Winter, 1982; Levin et al, 1985). Both R&D intensive sectors (particularly chemical and electronic products) and capital goods sectors have abundant technological opportunity. It has been shown elsewhere that low appropriability and concentration in capital goods is positively related to a greater spread of technological activities in capital goods among firms in the United Kingdom with different principal sectors of activity (Pavitt et al, 1987; see also Malerba and Orsenigo, 1988).

Our data confirm this pattern. Table 3 shows relatively low concentration of capital goods technology activities in large firms, together with a relatively high proportion of these firms producing some capital goods technology, albeit at a relatively low level. This is reflected in the significant and positive correlations shown in Table 4 between sectoral levels of concentration of technological activity and the Herfindahl index of concentration (aggregated according to the sectors of large firms' principal activity). This is because capital goods technology remains largely mechanical. Important mechanical inventions and innovations can be made without the specialized equipment and range of formal skills required in chemical and electronic technologies (Freeman, 1982). The spatial and design skills of individuals and small groups remain important sources of technology, as do users with experience in operating capital goods. Such competences are spread widely across industries and firms. They provide multiple possibilities of entry into promising areas of capital goods technology, thereby reducing the possibility of appropriation by first-comers. We hope to consider this explanation in greater econometric depth in future. In the next section, we shall see that the measurement of the technological activities of small firms through patent data in capital goods puts a different perspective on Canada's strengths and weaknesses.

THE IMPORTANCE OF LARGE FIRMS IN CANADA'S TECHNOLOGICAL ACTIVITIES

IN EARLIER WORK, we showed that international differences in the volume, trends and sectoral patterns of technological activity correlate significantly with those of large nationally-based firms, and that the technological performance of a country determines the domestic performance of these large firms — rather than the reverse (Patel and Pavitt, 1991). One reason for this is that the extent of internationalization of large firms' technological activities tends to be exaggerated. (Using a population of large firms similar to our own, Cantwell and Hodson [1990] estimated that only about 10 percent of the technological activities were undertaken outside their home countries in the mid-1980s, with no significant change over the previous 20 years.) In addition, the relative importance of large firms with respect to total national technological activities is often exaggerated. We contend that this is the case for Canada.

The differing structures of national systems of technological activity are shown in Table 5 — which compares the 11 countries that account for more than 95 percent of total OECD R&D funded by business enterprises, and of total U.S. patenting. The first two columns show the shares of total national patenting in the United States granted to the nationally-controlled large firms in our database; the third column shows the combined share for the other national sources (i.e. firms, government agencies, individuals). Assuming that U.S. patenting reflects national technological activities, Table 5 shows, therefore, that 11 percent of technological activity in Canada was performed by Canadian large firms, 16.9 percent by non-Canadian large firms, and the remaining 72.1 percent by other sources in Canada. Column four shows U.S. patenting by nationally-controlled firms from outside their home country, expressed (as in the other three columns) as a percentage of total national patenting in the United States. Again,

TABLE 5

The Importance of Large Firms in National technological Activities: 1981-86

	NATIONAL SOURCES OF PATENTING IN U.S.			PATENTING IN U.S. BY NATIONALLY CONTROLLED FIRMS FROM OUTSIDE HOME COUNTRY
	(3 COLUMNS TOTAL 100%)			
	LARGE FIRMS			
COUNTRY	NATIONALLY CONTROLLED	FOREIGN CONTROLLED	OTHER	(% OF NATIONAL TOTAL)
Belgium	8.8	39.7	51.5	14.7
France	36.8	10.0	53.2	3.4
FR Germany	44.8	10.5	44.2	6.9
Italy	24.1	11.6	64.3	2.2
N'lands	51.9	8.7	39.4	82.0
Sweden	27.5	3.9	68.6	11.3
Switz'land	40.1	6.0	53.9	28.0
U.K.	32.0	19.1	49.0	16.7
W. Europe	44.1	6.2	49.7	8.1
Canada	11.0	16.9	72.1	8.0
Japan	62.5	1.2	36.3	0.6
U.S.	42.8	3.1	54.1	3.2

NOTE:
All columns as percentage of total national patenting in the United States from 1981 to 1986.

by way of illustration, the technological activities of Canadian-controlled large firms outside Canada amounted to 8.1 percent of total technological activities inside Canada. The corresponding proportion for Dutch-controlled large firms was a massive 82 percent, and a miniscule 0.6 percent for Japanese-controlled large firms. Several important points emerge from this Table.

CANADIAN-CONTROLLED LARGE FIRMS

THE FIRST IS THAT NATIONALLY-CONTROLLED large firms account for a relatively small share of Canadian technological activities: 11 percent compared to more than 40 percent in the United States and Western Europe (combined), and more than 60 percent in Japan. The names of these Canadian firms, and numbers of U.S. patents granted, are listed in Table 6. In addition, in the first column of Table 7 we identify the sectors of technical specialization of these Canadian firms. We define "revealed technology advantage" (RTA) as the share of a firm (or

TABLE 6

CANADIAN LARGE FIRMS AND THEIR PATENTING IN THE UNITED STATES [1]

FORTUNE RANK	COMPANY	SALES[2]	EMPLOYMENT[3]	PRINCIPAL ACTIVITY	U.S. PAT. (1981-86)
232	Northern Telecom	3380.8	32577	Electronics	471
245	Canadian Development Corp	3228.1	18000	Rubber	170
051	Canadian Pacific	11300.0	120000	Metal	136
126	Alcan Aluminum	5467.0	70000	Metal	119
486	Inco	1468.0	22239	Metal	106
269	NOVA	2929.0	7800	Mining	45
286	Noranda	2614.9	26000	Metal	36
469	Massey-Ferguson	1535.0	23751	Mechanical	54
453	Domtar	1578.4	15408	Paper	28
443	MacMillan Bloedel	1642.8	14994	Paper	27
656	Ivaco	921.9	8200	Mechanical	24
555	Molson	1215.4	11000	Drink	15
430	John Labatt	1715.3	10500	Food	12
243	Petro-Canada	3262.5	6697	Mining	11
374	Stelco	1963.1	20612	Metal	10
291	Canada Packers	2562.2	13600	Food	8
382	Dome Petroleum	1889.8	6000	Mining	8
396	Seagram	1831.5	14000	Drink	7
411	Imasco	1779.2	55000	Drink	7
482	Dofasco	1487.2	13316	Metal	5
483	Genstar	1484.6	18000	NMinerals	5
442	Abitbi-Price	1650.1	14793	Paper	4
285	Hiram Walker Resources	261[illegible].4	10300	Drink	3
542	Consolidated Bathurst	1253.1	14400	Paper	2

NOTES:

1. Table sorted by the number of U.S. patents granted between 1981 and 1986.
2. Worldwide sales, millions of $ U.S. in 1984.
3. Average worldwide employment in 1984.

group of firms, or a country) in total patenting in the United States in a given sector, divided by the share of that firm (or group of firms, or country) in total patenting in the United States in all sectors. Some readers will note the similarity to the measure of "revealed comparative advantage" used in international trade. In both cases, an index above unity in a sector indicates relative strength, while an index below unity indicates relative weakness.

Table 6 shows that, apart from Northern Telecom, the principal activity of most of the large Canadian firms listed is based on the exploitation of abundant natural resources — metals, food, oil/gas and lumber. Their induced strength in the underlying technologies is required for the exploitation and processing of those natural resources and are reflected in Table 7. Canadian-controlled large firms had an RTA index of more than 1.5 during the period

TABLE 7

SECTORAL SPECIALIZATIONS IN CANADIAN TECHNOLOGICAL ACTIVITY: RTA INDICIES[1] IN 1981-86

		LARGE FIRMS		OTHER FIRMS[2]	COUNTRY[3]
		HOME	FOREIGN		
01	Inorganic chemicals	1.94	3.79	2.00	1.94
02	Organic chemicals	0.45	0.73	0.42	0.41
03	Agricultural chemicals	0.35	0.25	0.21	0.19
04	Chemical processes	1.34	0.74	0.78	0.80
05	Hydrocarbons, minerals oils etc.	0.75	4.54	1.61	1.32
06	Bleaching dyeing and disinfecting	0.00	0.14	0.17	0.12
07	Drugs and bio-affecting agents	0.22	1.00	0.57	0.71
08	Plastic and rubber products	1.18	1.34	0.90	0.98
09	Non-metallic minerals, glass etc.	0.79	1.03	1.36	1.23
10	Food & tobacco (processes and products)	1.70	2.24	0.94	1.55
11	Metallurgical and other mineral processes	2.14	0.95	0.98	1.05
12	Apparatus for chemicals, food, glass etc.	1.03	1.33	1.16	1.25
13	Gen. non-electrical industrial equipment	0.25	1.00	1.04	1.03
14	Gen. electrical industrial apparatus	0.79	1.10	0.89	0.85
15	Non-electrical specialized machinery	2.24	1.02	1.18	1.48
16	Metallurgical and metal working equipment	1.13	0.91	1.02	1.16
17	Assembling & material handling apparatus	1.47	1.39	1.12	1.38
18	Nuclear reactors and systems	0.00	0.51	0.22	0.21
19	Power plants	0.00	1.81	0.72	0.63
20	Road vehicles and engines	0.04	0.92	1.21	0.74
21	Other transport equip. (exc. aircraft)	0.55	0.79	1.63	1.78
22	Aircraft	0.00	2.22	1.08	0.97
23	Mining and wells machinery and processes	0.99	1.60	1.21	1.29
24	Telecommunications	3.67	1.09	1.15	1.40
25	Semiconductors	0.74	0.60	0.41	0.39
26	Electrical devices and systems	1.61	0.99	0.75	0.83
27	Calculators, computers, etc.	0.45	0.77	0.49	0.41
28	Image and sound equipment	1.20	0.39	0.89	0.76
29	Photography and photocopy	0.96	1.08	0.26	0.45
30	Instruments and controls	0.86	0.48	0.84	0.85
31	Miscellaneous metal products	0.78	0.90	1.29	1.52
32	Textile, clothing, leather, wood products	0.56	0.25	1.21	1.51
33	Other (not elsewhere classified)	0.55	3.30	1.13	1.59

NOTES:

1. See text for a definition of the RTA Index.
2. Other firms includes government agencies and private individuals.
3. Includes all U.S. patents of Canadian origin.

from 1981 to 1986 in telecommunications, specialized industrial equipment, metallurgical and other mineral processes, inorganic chemicals, food and tobacco, and electrical devices and systems.

In addition, columns one and four of Table 5 show that about 42 percent (i.e. 8/11+8) of the technological activities of these Canadian firms was performed outside Canada. More detailed data show that 31 percent was performed in the United States, five percent in the United Kingdom, and between one percent and two percent in both France and the Federal Republic of Germany. These strong linkages with the United States are not unique to Canada; our data show also that large firms from Belgium, the Netherlands and the United Kingdom also performed more than 25 percent of their technological activities in the United States.

Our data also show considerable variation across technologies in the extent to which Canadian large firms perform R&D abroad. Thus, among technologies of relative Canadian advantage, just over 20 percent of telecommunications is developed abroad, compared to just over 50 percent in metallurgical and other mineral processes. Generally, there is no significant correlation across technologies between the proportion developed by Canadian firms at home and their relative technological advantage.[8] Moreover, the sectors in which Canadian large firms tend to perform a higher proportion of their R&D abroad are not similar to those found among the world's largest firms. In aggregate these (world) firms tend to perform about 10 percent of their activity abroad, with a high of just under 20 percent in pharmaceuticals, and a low of about three percent in aircraft. For Canadian large firms, the high is 100 percent in power plant and the low is five percent in image and sound equipment. Overall, there is no significant correlation between the proportion of technological activities of all the world's largest firms undertaken abroad across sectors and the proportion for Canadian firms.[9]

FOREIGN-CONTROLLED LARGE FIRMS IN CANADA

CANADA'S TECHNOLOGICAL INTERDEPENDENCE with the United States is also reflected in the activities of American-controlled firms in Canada. Of the 16.9 percent of Canadian technological activities undertaken by foreign-controlled firms (see Table 5), 14.2 percent were from the United States and 2.6 percent from the United Kingdom. The major foreign-controlled firms patenting in the United States from Canada are listed in Table 8. Column two of Table 7 shows that, compared to their counterparts in other countries, foreign-controlled large firms were relatively stronger in hydrocarbons, mining and oil-drilling equipment, aircraft and power plant. The sectoral strengths of foreign large firms are also different from those of their Canadian counterparts. The correlation between their sectoral indicies of revealed technology advantage, as shown in columns one and two of Table 7, is 0.12 — which is not significantly different from zero at the five percent level.

NON-GIANT FIRMS IN CANADA: THE SILENT (TECHNOLOGICAL) MAJORITY

OUR ONE, POSSIBLY ORIGINAL, empirical result now emerges. Table 5 shows Canada as having a very high share of technological activities undertaken by the "Other" category (i.e. non-giant firms, government agencies and individuals). Only Italy and Sweden have similarly high proportions, and this remains the case even if patents granted to main government agencies are excluded. More than half of the patents in this "Other" category (representing 37 percent of total Canadian patenting) are granted to Canadian individuals. The recent survey by Amesse et al. (1990) shows clearly that a high proportion of these individuals are, in fact, self-employed entrepreneurs whose inventions do become commercialised.

The sectoral patterns of specialization for these non-giant firms, as measured by revealed technology advantage, are shown in column three of Table 7 and compared to those of Canada as a whole in column four. The two are very similar, with a correlation coefficient of 0.94; while the sectoral RTAs of large national firms (0.58) and large foreign firms (0.54) are less closely correlated with the national pattern. The following sectors emerge as fields of Canadian strength, as a result of the particular contribution of firms in this category: materials, other transport, metal products, and textile and wood products. In addition, there is above average performance over a range of capital goods' technologies.

ASSESSMENT

TWO CONCLUSIONS EMERGE from our analysis that strongly confirm earlier results.

First, sectoral patterns of Canadian technological advantage tend to reflect Canada's natural endowments: in particular, the extraction and processing of oil, gas, metals, lumber and other raw materials. This is seen in Table 7. A further, more detailed breakdown into nearly 100 technical sectors shows Canadian strength in related areas, including specialized machinery (paper, wood, other materials), aquatic devices, plant and animal husbandry, and a range of civil engineering technologies. Together with the already observed Canadian strength in telecommunications, these patterns confirm those reported in earlier studies by De Bresson (1989) and McFetridge (1990).

Second, the technological activities of large firms in Canada are heavily dependent on the United States. A high proportion of large-firm technology in Canada comes from American-controlled firms. A high proportion of Canadian large firms' R&D is performed in the United States.

We also found a high proportion (more than 70 percent) of Canada's technological activities take place outside very large firms, whether they are national or foreign-controlled. Furthermore, Canada's technological strength is

TABLE 8

TOP 10 NON-CANADIAN FIRMS PATENTING IN THE UNITED STATES FROM CANADA: 1981-86

COMPANY	NUMBER OF U.S. PATENTS
American Home Products Corporation	83
Exxon Corporation	80
Imperial Chemical Industries Plc	56
NCR Corporation	53
Allied Corporation	48
General Electric Compnay (U.S.)	40
E. I. Du Pont de Nemours and Company	41
Xerox Corporation	35
GTE Corporation	31
Merck	30

NOTE:
These 10 firms together account for 42 percent of the total patenting of non-Canadian firms from Canada.

TABLE 9

RELATIONSHIP BETWEEN CANADIAN REVEALED TECHNOLOGY ADVANTAGE AND IMPORTANCE OF NON-LARGE FIRMS AND RESOURCE-BASED TECHNOLOGIES

$$\text{RTA (Canada)} = \underset{(0.175)}{0.222} + \underset{(0.003)}{0.016^{*}}\ \text{NonL} + \underset{(0.196)}{0.389^{*}}\ \text{Resource}$$

RSq (Adj) = 0.42   F2, 30 = 12.72

NOTES:
1. For a definition of RTA see text. NonL refers to the share of private individuals and other firms for the sample as whole (i.e. sum of columns 3 and 4 in Table 3); Resource refers to a dummy variable equal to unity for those sectors that are closely related to the exploitation of natural resources and zero elsewhere.
2. The number in parenthesis is the standard error.
3. * = Coefficient is sigificantly different from 0 at the five percent level.

in sectors where large firms generally do not predominate and which have strong linkages to natural resources. These results are confirmed in Table 9. Here, we regress the revealed technology advantage index for Canada as a whole (Table 7, column 4,) against the share of the non-large firms for the entire sample (Table 3, columns 3 and 4), together with a dummy variable representing the natural resource-based sectors. Both explanatory variables have the expected (positive) sign and are significantly different from zero at the five percent level.

The question remains, however, as to whether the above pattern reflects the Canadian strength in smaller firms or weakness in the very large ones. Table 10 suggests a bit of both and (more important) that the preoccupation

TABLE 10

INDICATORS OF NATIONAL INNOVATIVE PERFORMANCE

	LARGE FIRMS 1	OTHER FIRMS 2	COUNTRY 3	IFRDGDP 4
Belgium	13.82	14.69	28.51	1.01
Canada	15.51	40.09	55.60	0.51
France	22.11	25.09	47.20	0.89
FR Germany	66.02	53.40	119.42	1.47
Italy	6.23	11.20	17.43	0.49
Japan	66.34	37.99	104.25	1.59
Netherlands	34.48	22.38	56.86	0.91
Sweden	33.77	73.89	107.66	1.46
Switzerland	89.37	116.02	215.39	1.63
United Kingdom	24.64	23.65	48.30	0.87

NOTES:

1. Columns 1 to 3 refer to U.S. patents per million population granted (1981-86) to large firms, other firms (including individuals and government agencies) and total country, respectively.
2. Column 4 is industry-financed R&D performed in industry as a percentage of GDP in 1983.

with large firms, and their R&D activities leads to serious under-estimation of Canada's technological performance. Table 10 compares technological performance in ten[10] countries as measured by per capita U.S. patenting (in aggregate, and segregated between very large and other firms), and by industry-financed R&D as a percentage of GDP. Two important conclusions emerge:

First, R&D performance so defined correlates more closely with the patenting performance of national large firms than with that of the non-large firms,[11] thereby confirming our earlier observation that R&D is an imperfect measure of innovative activity in firms with fewer than 10,000 employees.

Second, Canada's comparative technological performance among large firms (8th of 10) and industry-financed R&D (9th of 10) is considerably worse than its patenting performance among the other firms (4th of 10), where it is behind Switzerland, Sweden and Germany, but ahead of Japan, the Netherlands, France and the United Kingdom. Even allowing for advantages of geographic and linguistic proximity, this is an impressive — and unexpected — performance.

The standard explanation for the technological weakness of Canada's large firms is the dominance of inducements related to Canada's abundant natural resources. Through simple correlations of sectoral RTAs, we have identified other countries with strengths and weaknesses similar to Canada's: Australia, Sweden, and the United States are all countries well endowed with natural resources. Australia has an even weaker performance — as measured in terms of R&D and large-firm patenting — than Canada, but Sweden and the United

States perform much better. This suggests that abundant natural resources do not automatically preclude high levels of technological activities in large firms. Whether this weakness matters given Canada's proximity to, and interdependence with, the American R&D system brings us back to the old debate. Suffice to say that it did not work out that way between Sweden and Germany.

ENDNOTES

1. For a more detailed discussion of the uses and abuses of patenting statistics as a measure of technological activities, see Pavitt (1988).
2. For a detailed discussion see Dosi (1988).
3. For an analysis of the conditions under which this is likely to occur, see Teece (1986).
4. U.S. patenting slightly overestimates technological activities undertaken in the United States, compared to those in other countries, since firms have a higher propensity to patent at home than in foreign markets. It also severely underestimates the considerable volume of R&D undertaken in the USSR and other (former?) centrally-planned economies, the efficiency of which is low in innovation and diffusion, compared to market-driven economies (see Hanson and Pavitt, 1987).
5. For systematic evidence on intersectoral variations in the relative importance of these barriers, see Levin et al (1987) and Bertin and Wyatt (1988).
6. For a discussion of the varying patent practices of firms, see Bertin and Wyatt (1988). On the skew distribution of the value of patents, see Pakes and Shankerman (1983).
7. Government agencies are granted patents principally in government-funded R&D programs in defence, aerospace, energy and basic science. Recent studies in Canada and Italy show that, within the category "Individuals" are a significant proportion of commercially active small firms (Amesse et al, 1990; Malerba and Orsenigo, 1990).
8. Correlation coefficient is 0.13, which is not significantly different from 0 at the five percent level.
9. Correlation coefficient is 0.072 which is not significantly different from 0 at the five percent level.
10. We exclude the United States from these comparsions as the propensity of American firms to patent in their home country is higher than that of firms from other countries.
11. Correlation coefficents for the 10 countries listed in Table 10 are as follows (all significantly different from 0):
    R&D/GDP vs Large Firms = 0.85
    R&D/GDP vs Other Firms = 0.70
    R&D/GDP vs Country = 0.81

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DISCUSSANT'S COMMENT

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HOW IMPORTANT ARE LARGE CANADIAN FIRMS in terms of Canadian technological production activities? This is one of the major issues addressed in the text by Patel and Pavitt. To some extent, the question revives the old debate as to the weaknesses of technological activities in Canada, but from an interesting angle.

The authors' analysis is based on a study of patents taken out in the United States from 1981 to 1986, by foreign nationals from various OECD countries and, in particular, by 686 very large firms based in those countries. In Canada's case, 24 Canadian firms are included in this select group of large firms. The second half of the study focusses specifically on Canada and its large firms, then it goes on to show that in relative terms, the technological production of large Canadian firms ranks lowest among 11 industrialized countries.

Using patents taken out in the United States as their basis of measurement, the authors show that large firms in Canada control only 27.9 percent of total production. This figure is broken out in Table 5, which shows that large firms under Canadian control account for 11.0 percent, while large firms under foreign control (subsidiaries) account for 16.9 percent of total production.

Accordingly, 72.1 percent of Canadian technological production is the work of "others" — notably private individuals and government agencies. In the context of Canadian production, other smaller companies account for 28.6 percent and government for 6.5 percent.

This result largely confirms what has already been observed in my own work from patents issued in Canada to Canadians between 1978 and 1980.[1] Using this data, individual inventors accounted for 41.6 percent of technological production, governments for 10.5 percent and businesses for 47.9 percent. The 20 Canadian firms that obtained the most patents accounted for only 18.7 percent of patents issued to Canadian organizations. These firms are included in the list of 24 identified by Patel and Pavitt.

As can be seen, our results appear to run in parallel. Moreover, it should be noted that the weights of Canadian firms are probably inflated by the fact that the comparisons are based on patent data taken out in the United States. The bias occurs because there is a lower propensity among private individuals, governments and small businesses to secure patents abroad.

Canada is not unique in its pattern of technological production. Table 5 shows that the weight of large companies in Italy and Switzerland is no more than 35.7 percent and 31.4 percent of the total technological production of these countries, compared to the United States. The assumption that individuals and smaller firms from these countries tend to patent less[2] in the United States than do Canadians, places these countries and Canada in an analagous position.

However, Canada is distinguished by its relative technological advantages compared to other countries. Without exception, Canada's large firms do not operate in areas characterized by high technological opportunities. The relative technological advantages are determined primarily by the activity of smaller firms and private investors. Moreover, these relative technological advantages complement the long-recognized strengths that Canada has in natural resoures.

As the authors underline well, it remains an open question whether these distinguishing features reveal a fundamental weakness or strength.

Certainly, the study helps to explain the relative technological weakness observed by several authors. Canada's large firms do not have a strong presence in the latest technological fields. Should the vitality of Canada's small firms and inventor-entrepreneurs be considered a strength? Again, I am not sure. I do, however, feel that this characteristic of Canadian technological activity underlines the fragile nature of the stakeholders and the related difficulties in identifying the scattered elements which form our advantages.

Many analysts have pointed with pride to the ongoing creation of new high-tech firms in Canada, particularly since the early 1970s. Yet, nearly 50 percent of all such companies have fewer than 20 employees.

In addition, in a survey of the high-tech sector in Canada for the period 1989-90 (*Directions* 89/90), Ernst & Young determined that 41 percent of respondents had made strategic alliances with Canadian and foreign firms. Fifty-six percent (of the 41 percent) of these alliances were with foreign firms; 215 with Canadian firms and 21 percent with both foreign and Canadian firms. Is this one of the effects of the absence of large Canadian firms in these advanced sectors? Small firms seek alliances and Canadian partners of significant size are scarce.

It would be appropriate at this point to cite the concept proposed by Cantwell of the growth through emerging interrelationships between dynamic and conventional technologies as key elements of technological capability.

Consistent with this concept, while Canada has a relative technological edge in the conventional resources sector in which most of its large firms are active, future developments in biotechnology (particularly in non-pharmaceutical areas) may serve us better. Such developments can create opportunities for building interrelationships between our conventional resource capability and dynamic technological fields. These interrelationships could also better serve small firms and entrepreneurs in Canada by promoting significant alliances with other domestic firms.

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2. For instance, Sirilli, *Research Policy*, Vol. 16, No. 2-4, 1987, p. 157-74 indicates that only 20 percent of private inventors in Italy apply for patents abroad.

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4

Host Country Benefits of Foreign Investment

INTRODUCTION

THE PROSPECT of acquiring access to modern technology is perhaps the most important reason why countries try to attract foreign investment. By inviting multinational enterprises (MNEs) to invest within their national boundaries, host countries hope to gain access to technologies they cannot produce themselves. Foreign direct investment (FDI) can also lead to indirect productivity gains for host country firms through the realization of external economies. Generally such benefits are referred to as "spillovers" — which fairly describes the way the influence is transmitted.

There are several ways technology spillovers can occur. Multinational firms may, for instance, increase the degree of competition in host country markets thereby forcing existing inefficient firms to become more productive by investing in physical or human capital. MNEs may also undertake training of labor and management which may then become available to the economy in general. Another possible channel for spillovers is the upgrading of local facilities and suppliers of services to meet the higher standards of quality control, reliability and speed of delivery required by the technology and operating methods of the foreign-owned company.

The purpose of this paper is to discuss the very different conclusions that can be drawn about productivity spillovers from foreign investment. Since the technology transferred abroad by multinationals constitutes the potential for spillovers to local firms, I begin by considering MNEs as carriers of technology and examining the determinants of their technology transfer activities. I go on to explain the concept of host country spillover benefits and describe the various forms these benefits can take, both within and between industries. I then summarize the evidence regarding the relative magnitudes of the various forms of spillovers. Next, I discuss host country policy measures which can accelerate both the MNE affiliates' technology imports and the diffusion of their technology in the host economies. Finally, I summarize the paper and offer my conclusions.

INTERNATIONAL TECHNOLOGY TRANSFER AND THE MNE

THE ATTENTION DIRECTED to the role of multinationals in the international transfer of technology is not surprising for at least two reasons. First, multinational corporations own, produce and control most of the world's advanced production technology and are responsible for a major part of the world's research and development effort. R&D is crucial for MNEs, since such effort creates ownership-specific advantages that enable firms to operate in foreign countries (see Caves, 1982). Second, MNEs and their host countries often have different objectives with respect to technology transfers. The technology recipients are interested in obtaining technology at as low a price as possible. The MNEs, on the other hand, want to protect their intangible assets and other similar advantages that enable them to make foreign investments.

The characteristics of the technology brought overseas by multinationals depend on several factors — one of which is the form of engagement by the multinationals. There is substantial evidence to support the claim that the more modern and complex the technology, the less willing a multinational is to accept any arrangement other than a wholly-owned subsidiary in order to avoid leakage. For example, Mansfield and Romeo (1980) found that technologies transferred to affiliates were consistently of a later vintage than those sold to outsiders. The average age of a sample group of technologies at the time of their first transfer to subsidiaries in developed countries was 5.8 years (9.8 years for those transferred to developing countries) whereas the corresponding figure for outside licensing and joint ventures was 13.1 years. Results reported for Canada by McFetridge (1987) are consistent with these findings, confirming that the type of technology influences the mode of transfer and that transfer lags tend to be shorter for intra-firm (internal) transfers than for other transfer types.

Also, Behrman and Wallender (1976), in a detailed study of technology transfers, emphasized the qualitative differences between technology transfers within multinationals and transactions between independent parties. More advanced technologies were transferred on an intra-firm basis. Behrman and Wallender also stressed the continuous character of intra-firm technology flows and identified five general mechanisms of technology transfer, that are more-or-less intensively used throughout the lifetime of an affiliate. Namely:

- documentation, in the form of manuals and technical publications,
- instruction, education, and training of employees,
- visits and exchanges of technical personnel,
- development and transfer of specialized equipment, and
- trouble shooting, i.e. continuing oral and written communication to solve problems.

Furthermore, various characteristics of the transferring companies seem to influence the cost of technology transfer and, thus, the type of technology brought overseas by multinationals. For example, Teece (1976) demonstrated learning by doing in international technology transfers, in the sense that the transfer costs decreased with the number of transfers. Moreover, Davidson (1980) suggested that transfer costs decline as firms become more familiar with international operations in general, and with their individual markets in particular (see also Blomström and Zejan, 1991). Thus, a firm's experience in foreign operations is likely to accelerate the technology transfer process to affiliates, other things being equal.

Host country characteristics also influence the level of technology exports. To a large extent, the host country's technological capability, in terms of a well-educated work force for example, determines what sort of technology is transferred. As Teece (1976) finds, the cost of transferring specific technologies decreases with increasing capabilities in the host economies: Behrman and Wallender (1976) and Cortes and Bocock (1984) provide illustrative examples for certain industries. Kokko (1990) in a study of technology imports by American affiliates in 32 countries, also concludes that the amount of technology transferred increases with the host country's technological capability (see also Mansfield and Romeo, 1980; Chen, 1983; and Dahlman, et al, 1987). It seems safe to conclude, therefore, that the more technology is transferred, the more advanced is the recipient country or firm.

The willingness of multinationals to bring technology is also influenced by host country policies. Many countries apply various technology transfer requirements that can require MNEs to employ a minimum of local labor, make technologies available for local firms, restrict imports, or use local suppliers. These requirements increase the cost of certain types of technology transfer and should, therefore, depress the affiliates' technology imports (see McFetridge, 1987 and Grosse, 1989 for evidence).

FOREIGN INVESTMENT AND SPILLOVERS

IT CAN BE ARGUED that the imports of technology by MNE affiliates lead only to a geographical diffusion of technology, but not to transfers to new users, because the ownership and control of technologies are largely kept in the MNEs' possession. However, since technology is to some extent a public good, foreign investment can also result in indirect gains for host countries through the realization of external economies or spillovers. I shall now examine both the influence of foreign firms on the efficiency of their host country competitors ("intra-industry spillovers") and the influence of foreign firms on their local suppliers and customers ("inter-industry spillovers").

INTRA-INDUSTRY SPILLOVERS

THERE ARE SEVERAL WAYS in which intra-industry spillovers may occur. Competition is one possible mechanism. Although multinationals may suffer from some disadvantages vis-a-vis the domestic entrants — for example, knowledge of consumer and factor markets and the favour of local governments — it is likely that they enjoy other and more important advantages in overcoming barriers to entry such as capital requirements, risks, and research and development intensity. MNEs might therefore find it easier to enter markets where barriers to entry for new firms are high (see Gorecki, 1976, for affirmative evidence). Further, foreign entry might be expected to increase competition in host country markets and force inefficient domestic firms to adopt more efficient methods. Also, existing inefficient local firms may be forced by the competition of foreigners to become more productive by investing in physical or human capital, or simply by raising productivity. Moreover, the least efficient local firms may be driven out of business, thus making the resources they had controlled available to more productive companies.

Another source of gain to the host economy is the training of labor and management which takes place in the multinationals and may then become available to the economy in general. The local employees who are trained in the multinationals may find it advantageous to exploit their gains by moving to locally-owned firms or by becoming entrepreneurs on their own. An employee trained and educated by, or with a certain level of experience in, a multinational corporation may add much more to the profitability of a locally-owned firm with no such employees than to that of the multinational that provided the training because, in the foreign-owned firm, the trained employee is only one of a large number of similar employees. Since managerial talent, scientists and skilled workers are in short supply in developing countries, this type of spillover efficiency may be more important there than in developed countries.

A third possible source of intra-industry spillover efficiency benefit is that MNCs may speed up the transfer of technology. For both process and product technology, such a transfer is a central activity of MNEs and this may stimulate domestic firms to hasten their access to a specific technology, since they would not otherwise have been aware of the technology's existence, or they would not have considered it profitable to try to obtain the technology.

Several of the early studies of foreign investment provided anecdotal evidence on indirect productivity gains for host countries from the presence of multinationals (see Dunning, 1958; Brash, 1966; Safarian, 1966; and Deane, 1970). More direct (although rough) tests of foreign investment and spillovers were undertaken in a study for Australia by Caves (1974), for Canada by Globerman (1979), for Hong Kong by Chen (1983), and for Mexico by Blomström and Persson (1983) and Blomström (1989). Although none of these studies undertook to analyze the nature of spillover efficiency in any depth, they all found evidence to support the spillover benefit hypothesis. Productivity levels of domestic firms increased with the foreign subsidiaries' share of the market.

The fact of technology leakage from multinationals to host country competitors was also confirmed by Mansfield and Romeo (1980) in a detailed study of technology exports by American firms (see also Mansfield, 1982). They found that in about one-third of the cases studied, the introduction of MNE technology abroad increased the speed at which competing products or processes appeared by at least 2.5 years. Moreover, they used information from a sample of British firms to examine whether these had been affected by technology transfers by U.S.-based firms to their subsidiaries in the United Kingdom. Over half of them believed that at least some of their products and processes had been introduced, or were introduced more quickly, because of the transfer of new products or processes by American multinationals.

Also Blomström and Wolff (1989), in a study of Mexican manufacturing industries, found that there were notable productivity spillovers within industries. Furthermore, they tried to measure the size of these spillovers by asking if they were large enough to generate international productivity catch-up. They found strong evidence that the presence of multinationals acted as a catalyst to the productivity growth in Mexico and that foreign direct investment (FDI) accelerated the process of productivity convergence between Mexico and the United States.

There is also some evidence confirming the relationship between spillover efficiency benefits and industrial and national characteristics. A recent study by Cantwell (1989) analyzes the impact of American investment in Europe on the competitiveness of European industries and firms. He found that the effects vary widely between countries and industries. According to Cantwell, countries are likely to enjoy spillovers only in the areas in which their firms have been successful in the past. Hence, the competitive stimulus of the entry of American firms into Europe helped to spur an indigenous revival in areas of traditional technological strength.[1]

Also, Blomström (1986) in a study of the effects of foreign investment on the productive efficiency of the industrial structure in Mexico, points to the competitive stimulus of multinational participation as an important channel for spillovers. In fact, these findings suggest that the competitive pressure induced by the foreign firms is the most important source of spillover efficiency. Although there is no (other) statistical investigation to support this conclusion, there is considerable indirect support for it in the literature. A number of earlier studies also confirmed that the rate of entry of multinationals is negatively related to the changes in market concentration (see Rosenbluth, 1970; Dunning, 1974; and Knickerbocker, 1976). Thus, it seems that foreign investment tends to reduce the level of concentration and increase competition in host country industries, which in turn may promote greater efficiency in domestic firms.

The available evidence on spillovers from the training of employees by multinationals is more sketchy and comes mainly from developing countries. Katz (1987) points out that many managerial people in locally-owned firms in Latin America started their careers in foreign companies. He goes on to claim that the host countries have recieved important spillovers in this way. A study of recent development in Southeast Asia by Yoshihara (1988) points up the importance to Chinese-owned firms of both training in foreign companies and education in foreign schools. Gerschenberg (1987), using career data from 72 top and middle level managers employed in 41 firms in Kenya, concludes that multinationals have played an important role in the dissemination of managerial know-how in that country. Wasow (in Shelp et al, 1984) describes the loss of trained employees to other firms as one of the main ways in which insurance industry technology is transferred outside the company he studied (AIG) — "in the Philippines, AIG is known as the 'training ground' for the insurance industry" (p. 45). Behrman and Wallender (1976) found not only that managers trained by multinationals move on to join other firms, but also that multinational companies transfer management technology through assistance to their local suppliers (see also Gabriel, 1967; Balasubramanyam, 1973; Lall, 1980; Buckley and Artisien, 1987; and Lipsey, 1990). Thus, the available evidence from developing countries seems to suggest that there are spillovers from the training of employees by multinationals.

Even if technology leaks out from multinationals to host country firms, such leakages do not occur automatically; they generally require major investment by the recipient. Mastering a technology is an active process. Searching for information, reverse engineering, personnel training for new production methods, are only some of the factors that make the learning process costly and time consuming. Thus, it is through the investment mechanism that new technologies are diffused. This point will be expanded below.

INTER-INDUSTRY SPILLOVERS

THE IMPACT MADE by foreign subsidiaries on their local suppliers and customers is another potential source of spillover efficiency benefit. New technology brought in by multinationals may stimulate local suppliers of intermediate products to improve product quality and lower cost in order to compete for the MNE market. New products introduced by the foreign firms may also stimulate improved productivity in the local firms purchasing these products.

There are few systematic analyses of the effects of foreign participation on industries outside their own, although this presumably is an important source of technology transfer. Some studies have shown that local purchases of inputs tend to increase as the multinationals' subsidiaries mature (see Safarian, 1966; Forsyth, 1972; and McAleese and McDonald, 1978) but none of these investigations deals specifically with spillover effects. However, some case studies have touched on the spillover issue. In his study of American investment in Britain, for example, Dunning (1958) found that foreign firms were generally engaged in the training of local suppliers and suggested that inter-industry spillovers were significant. Another suggestive study, by Brash (1966), discussed the impact made by General Motors in Australia on its local suppliers by insisting that they meet GM standards of quality control. Lim and Pang

(1982), who surveyed the electronic industry in Singapore, found that multinationals were willing to assist in the establishment of local supplier firms by suggesting entrepreneurial possibilities and providing technical assistance, financial aid, managerial advice, guaranteed business and marketing information. Also Reuber, et al (1973), Behrman and Wallender (1976), Germidis (1977), and Lall (1980) provided some empirical evidence on spillover effects of foreign investment on industries outside their own, but no one has followed up this line of research with statistical analyses.[2]

More research is needed before drawing strong conclusions about inter-industry spillovers. Nonetheless, there is limited evidence to suggest that technology is leaking out to the multinationals' suppliers and customers. Some recent developments also seem to suggest that this kind of spillover might become more important in the future. Data show, for instance, that Swedish multinationals are using independent subcontractors to an increasing extent, both at home and abroad (see Eliasson, 1985), which would increase the potential for "backward" spillovers.

Because of the rapid technological change that is currently taking place, I also believe that spillovers to the multinationals' customers in the host economies will become much more important in the future. The reason for this is that the newly emerging technologies, like microelectronics and the new generation of computer-based automation and information technologies, are generally so knowledge- and research-intensive, and therefore so expensive to develop, that only a few large firms (MNEs) can afford such efforts. Thus, small countries facing the technological revolution must accept a certain degree of dependence on the MNEs' technology. For them, it is more important to have the capability to *use* advanced technologies than to *produce* them — this is clearly exhibited in the historical experience of the smaller European countries (see Blomström and Meller, 1991). Small countries should, therefore, put less emphasis on developing entirely new, cutting-edge technologies, than on promoting the widespread dissemination of technological capabilities throughout the economy.

In discussing these new technologies, it is essential to recognize that their main influence on the behaviour of the economic aggregates is indirect rather than direct. For example, while the computer industry by itself makes only slight contributions to the output and employment in the countries where production takes place, the computer has applications everywhere. In all countries, computers are now used in every conceivable service, but they also have different functions within individual enterprises (administration, production, design, marketing and research). Thus, access to these new high-technology fields will become increasingly essential if firms are to sustain competitiveness.

Moreover, it has been shown that while thresholds in some advanced technology areas are high for both R&D and investment, there are relatively low threshold costs in a number of software applications and in many specialized areas of instrumentation and machinery (OECD, 1989). This suggests that the recently emerging technologies open up many new possibilities and opportunities for small countries. The fact, for instance, that Sweden today produces advanced technologies does not mean that it has become independent of foreign technology. On the contrary, Sweden is more dependent on foreign technology today than ever before. For example, the Swedish success in high-tech areas, such as telecommunication equipment, is based partly on American technology (see Blomström, Lipsey and Ohlsson, 1989). Thus, by importing technology and high-tech components from the United States (and other countries) Swedish firms can stay competitive in world markets as well as in various high-tech niches.

This also suggests important implications for trade policies. Since technology has become so complex and expensive to develop, access to foreign products and technology via imports is now more important than ever for firms in *all* countries, including the United States. Import restrictions may have devastating effects on economic growth as shown, for example, by the recent experience of Brazil. In 1984, the Brazilian Congress voted overwhelmingly to reserve the market for micro- and mini-computers for national manufacturers for a period of eight years. As a result, after six years of limited access to the world computer revolution, the cost of Brazilian personal computers is generally twice that of their foreign equivalents on the international market; a facsimile machine costs seven times more than a foreign equivalent (*New York Times*, July 9, 1990). This policy has become too costly to retain and Brazil has therefore decided to abandon it.

HOW TO INFLUENCE THE SIZE OF SPILLOVERS

THE POLICY MEASURES that should be adopted by countries hosting multinationals to encourage these firms to transfer more technology, thus increasing the potential for spillovers, have been widely discussed over the years. Generally, it has been thought that in order to increase benefits from an MNE project, governments should use different types of proscriptions. Accordingly, many countries have begun to frame the environment within which multinational firms will operate and have introduced various performance requirements. Special attention has been given to policies regarding technology transfer, and a number of measures intended to encourage multinational firms to increase their technology transfer, including requirements for local content and local R&D, have been introduced.

A different view on how to influence the potential and the size of spillovers has recently been suggested by Wang and Blomström (forthcoming). They develop a model in which international technology transfer through foreign direct investment emerges as an endogenized equilibrium phenomenon, resulting from the strategic interaction between subsidiaries of multinational corporations and host country firms. This model highlights the essential role played by competing host country firms in increasing the rate at which the multinationals transfer technology and suggests that host countries of multinationals should concentrate on supporting their domestic firms in their efforts to learn from the foreigners, rather than stipulating performance requirements for the multinationals, if they want to increase the technology transfer from the multinationals.

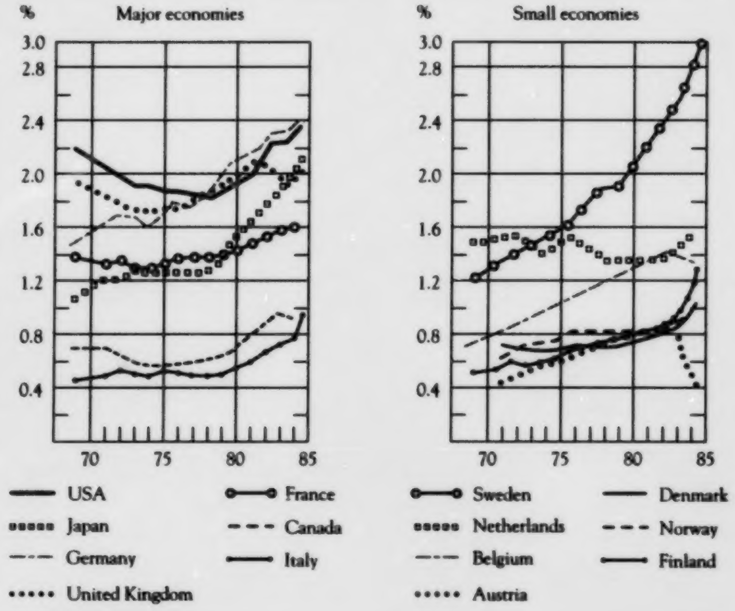
Empirical evidence from American majority-owned foreign affiliates in some 32 countries largely confirms this theoretical hypothesis (see Kokko, 1990). Kokko's findings suggest that technology imports by MNE affiliates increase with the income level of the host country and (proxies for) the competitive pressure in the host economy, and decrease with the level of distortions and various host country performance requirements. The negative impact of different performance requirements on the multinationals' technology transfer activities is also confirmed by McFetridge (1987), while Lake (1979) demonstrates the positive effect of competition. In his study of the semi-conductor industry in the United States and the United Kingdom, Lake found that technology diffusion was faster the more competitive was the industry in which it occurred.

These findings have important policy implications. If the MNE affiliates actually adapt their conduct to local conditions (for example, local competition and supply of educated labor), then the set of instruments for the host-countries' technology policy increases notably. Rather than relying on controls and direct supervision of MNEs to secure some benefits from their operations, local governments have the option to create an environment that fosters spillovers and continuing technology transfer. Supporting competition in the industry where a MNE enters, through subsidies to education and training in local firms, for example, or by inviting another competing MNE, has dual benefits. First, the MNE is forced to adjust to competition by upgrading its production processes and importing technology, in step with the competitiors' productivity improvements. Second, the continuous inflow of technology increases the spillover potential while the support to local firms increases the likelihood of actual spillovers. In other words, a 'virtuous circle' of productivity and technology growth is possible, in contrast to the 'vicious circle' that occurs when the MNE is allowed to operate without competition, and risks falling further and further behind global standards.

Recently there has also been concern, both in home countries and in host countries, over the research and development activities of the multinationals. Home country governments are mainly worried about the negative effects of R&D investment overseas and emphasize the risk of facilitating (for actual or potential competitors) the access to technology on which the home country's competitive position relies (see Zejan, 1990). In the host countries, there is generally a positive attitude towards the development of R&D activities in the foreign subsidiaries. Such activities are expected to contribute in different ways to local technological capability and have come to be identified as vital to industrial competitiveness.

FIGURE 1

R&D EXPENDITURE IN THE BUSINESS ENTERPRISE SECTOR AS A PERCENT OF VALUE ADDED



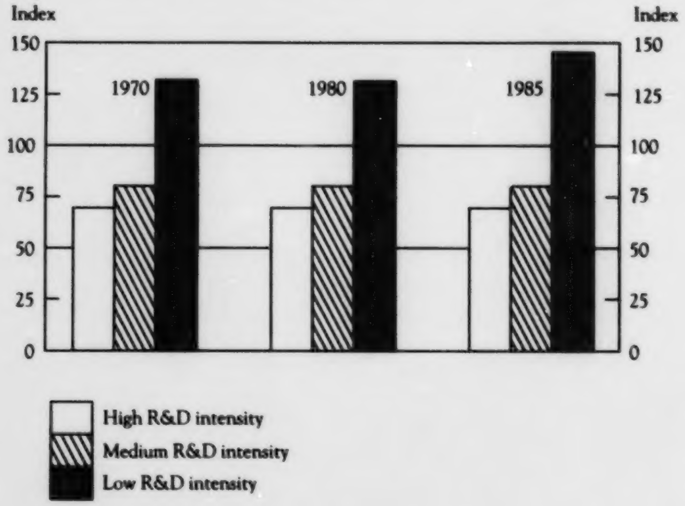
SOURCE: OECD 1986

Research alone, however, does not guarantee that the economic benefits of research investment will be realized by the nation making the investment. As we have shown in other studies, the competitiveness of countries can behave very differently from the competitiveness of the firms located there, if these firms produce abroad as well (see Lipsey and Kravis, 1985 and Blomström and Lipsey, 1989). National policies aimed at improving the competitiveness of a country may therefore fail if they create or subsidize assets that improve the competitiveness of firms that can exploit these assets in other countries. Let me give one example.

For many years the Swedish government has supported firms undertaking research and development in Sweden. The idea behind this policy is that an increase in research and development will upgrade Swedish production over time and raise Sweden's competitiveness with respect to high-tech products. As can be seen from Figure 1, in the 1980s Sweden became the OECD country with the highest ratio of business enterprise R&D to industry output.

FIGURE 2

Global revealed comparative advantages of Sweden[1] 1970-85



[1] Revealed comparative advantages are for a sector defined as the ratio between the country's sectoral share of OECD exports and its overall export share.

SOURCE: Blomström, Lipsey and Ohlsson, 1989

So far, however, this policy has had little impact if we look at the types of products Sweden is exporting. Dividing Swedish exports into three categories, high-, medium-, and low-tech, it can be seen (from Figure 2) that there has been no shift toward exports of high-tech products in Sweden since 1970. On the contrary, the large devaluation in 1982 increased the competitiveness of low-tech industries.

There are several possible explanations as to why Swedish exports have not shifted toward high-tech products, despite the increased R&D activities of Swedish firms. One is that research and development is a long-term investment and the effects have not yet appeared in Swedish exports. If this is correct, a shift to high-tech export may still be expected. However, given that Swedish firms have spent more on R&D (as a percentage of value added) than their main competitors since the mid-1970s, and substantially more than even American firms since the end of the 1970s, this is not very likely.

A second possibility is that research and development has been misdirected in Sweden, and that the output from it will never appear in the trade statistics. According to OECD (1986), there may be some truth in this explanation.

In general, OECD suggests that Swedish R&D is inefficient in generating the production and export of new products.

Third, it is argued that Swedish R&D has been directed mainly toward rationalizing techniques for the production of low-tech products, such as pulp and paper. This has certainly been the case, but the weighted impact of these improvements has not been large enough to prevent Sweden from falling behind many of its competitors in terms of per capita income.

The fourth and final possibility is that Swedish multinationals base their R&D for the entire organization in Sweden, while carrying out a large portion of high-tech production abroad. In other words, Swedish firms' R&D efforts in Sweden might raise their competitiveness in high-tech products, but the firms do not find Sweden the most suitable location for high-tech production. Since the results of R&D are transferable across international borders within firms, Swedish multinationals might choose to do their high-tech exporting from countries other than Sweden. At least two observations support this explanation for why Swedish R&D does not generate production and export of Swedish high-tech products. One is that more than 85 percent of the R&D undertaken by Swedish MNEs is based in Sweden (Swedenborg, 1988); the other is that the competitiveness of Swedish multinationals (defined as their share of world or developed country exports) has increased since the mid-1960s, while that of Sweden, generally, has decreased (Blomström and Lipsey, 1989).

CONCLUSION

THE SPECIFIC CONCERN of this paper has been to review the evidence on the very different conclusions that can be drawn from productivity spillover of foreign direct investment. The general picture that emerges from the empirical literature on spillovers is that such effects exist, and that they may be substantial both within and between industries, but there is no strong evidence on their exact nature. Moreover, recent research suggests that spillovers vary between countries and industries and are likely to increase with the level of local capability and competition.

The perception of spillovers as endogenous phenomena complicates the discussion of what policy measures can accelerate the MNE affiliates' technology imports and the diffusion of their technology in the host economies. Evidence suggests that various technology transfer requirements may not always produce the intended results. At best, requirements may secure diffusion of a large share of a smaller technology stock. Alternative policies, such as support to education and competition in the domestic markets may, on the other hand, increase both the inflow of technology and the absorptive capacity of domestic firms. Thus, from an investment policy perspective, prescriptions seem more effective than proscriptions. The reason is not only that individual host countries have limited possibilities to influence the multinationals in their choice of production location, but also that technology transfer via MNEs depends, to a large extent, on the performance of the host country firms.

Foreign technologies may, of course, be acquired in other ways than through foreign direct investment. Multinationals may transfer technologies through several other arrangements; joint ventures, licensing, and technical service contracts for example. Technology may also cross international borders through trade. Empirical evidence suggests, however, that these different avenues of technology transfer should be seen as complements rather than substitutes. The type of technology seems to influence the mode of transfer and certain advanced technologies are simply not available through means other than foreign direct investment. Thus, keeping the doors open for the acquisition of technical information through several different channels will eventually lead to more technology transfer and higher productivity growth.

Another issue, which is indirectly related to the spillover question, has to do with the economic benefits of R&D. Several studies have shown that the fruits of R&D are transferable across international borders within firms and that they can be realized in geographic locations other than where the R&D activity was originally undertaken. Thus, subsidising research and development in multinational firms (foreign or domestic) does not guarantee benefit to the nation providing the subsidy if the economic environment in the country at large is not favourable.

In summary, there is strong evidence that multinational firms have contributed to a geographical diffusion of technology and that active host countries can obtain access to modern technology via foreign direct investment. With the increasing global interdependence in the economic and technological spheres it can also be expected that multinationals will remain an important vehicle in the international diffusion of technology.

ENDNOTES

1. Cantwell's model is interesting in the sense that it stresses the importance of the relative technological capacity of the sector in the host country in analyzing the effects of foreign investment. I find it troublesome, however, that this technological competence is, in a way, given from the beginning in his analysis, because that makes his model rather "deterministic". How can his static model, for instance, explain the success of Japanese firms on the world market? Or the emergence and success of Newly Industrializing Countries? An alternative, dynamic approach is given in Wang and Blomström (1989), discussed below.
2. Although there are no statistical analyses of foreign investment and inter-industry spillovers, there are several studies of technological or R&D spillovers between industries. The work of Bernstein is particularly relevant (see e.g. Bernstein 1988, 1989, and his chapter in this volume). See also Terleckyj (1980), Scherer (1982), Jaffe (1986), Wolff and Nadiri (1987), Bernstein and Nadiri (1989), and Mohnen (1990).

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DISCUSSANT'S COMMENT

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MAGNUS BLOMSTRÖM addresses an issue of importance to many of the authors in this volume and provides a line of analysis in offering recommendations which, in some circles, would be considered iconoclastic. The issue is: where will future multinational enterprises conduct their R&D, and will the result have adverse consequences for Canada? He suggests, as do others, that MNEs are likely to centralize their R&D in each of the major market areas — the U.S., Europe and Japan — but probably not in Canada. He concludes, however, that the absence of R&D conducted in Canada by foreign firms should not really matter all that much to Canadian authorities.

This conclusion emerges because MNEs have largely broken the link between R&D and production, and because a large portion of the rents generated by MNE activity is captured in higher wages, there is also the consideration that the largest contribution MNEs make to a host economy comes in the form of spillovers which enhance the performance of other sectors of that economy.

This leads Blomström to suggest that the focus of Canadian policy should be on attracting MNE *production*, not R&D activities, and on stimulating the dissemination of their technological spillovers. The principal tools to accomplish these goals are the granting of sole foreign ownership (rather than promoting joint-ventures) and the enhancement of competition in the local market. The promotion of Canadian national interests, he argues, would best be served by avoiding R&D performance requirements and restrictions on high-tech acquisitions. Such a recommendation is sure to generate controversy, both within this volume and outside it.

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5

R&D Capital, Spillovers and Foreign Affiliates in Canada

INTRODUCTION

THE PURPOSE OF THIS PAPER is to investigate the determinants of and returns to research and development (R&D) activities for firms operating in Canada. Particular focus is placed on a comparison between Canadian-owned firms and foreign affiliates. An analysis of the determinants of R&D activities highlights whether the conditions governing R&D growth differ between Canadian-owned firms and foreign affiliates. Throughout the paper these are frequently referred to as the "two groups". An important aspect of the comparison relates to the issue of underinvestment or overinvestment in R&D. The calculation of the rates of return to R&D for both Canadian-owned firms and foreign affiliates provides insight into the adequacy of R&D expenditure in Canada.

Current R&D expenditures lead to a stream of future benefits. As with other forms of capital expenditure, R&D expenditures lead to the accumulation of a stock of capital, in this case R&D capital. Thus, the benefits to R&D activities must be measured and evaluated in terms of the rate of return to R&D capital stock. This type of evaluation is superior to analyses of ratios of R&D expenditure to gross national product (GNP). Since the latter ratios merely indicate average propensities to spend on R&D without reflecting under- or overinvestment in R&D capital stock. (Indeed, owing to inherent weaknesses within the latter methodology, gross inaccuracies can arise from such comparisons.) As an example, let us look at health-care services. The fact that Canada spends eight percent of GNP on health care compared with 12 percent spent by the United States does not imply that Canadians underspend on health services; nor for that matter do the ratios show that Americans are healthier than Canadians. The adequacy of health-care services must be evaluated in terms of rates of return.

A distinctive feature of R&D investment relates to the issue of appropriability of the benefits accruing to R&D performers. Firms undertaking R&D investment are not able to exclude others from freely obtaining the benefits of new products and processes. There is a "public good" aspect to R&D capital accumulation. The benefits from R&D cannot be completely appropriated and, inevitably, there are spillovers, which create a wedge between the private and social returns to R&D. R&D spillovers are ideas freely borrowed by one firm from the knowledge of another firm. Private rates of return to R&D capital are the returns to the R&D *performers*, and social rates of return are the returns to the R&D *users*.

In this paper, private and social rates of return are evaluated for Canadian-owned firms and foreign affiliates. The difference between these returns indicates the adequacy of R&D investment. If the social rate of return exceeds the private rate, then the benefits to the users in society exceed the benefits accruing to the performers; hence, there is underinvestment in R&D capital. The converse situation arises if the social rate of return is less than the private rate.

Since the knowledge base for production activities expands free of charge, spillovers will generate cost reductions for the receiving firms. Meanwhile, the demand for R&D capital on the part of recipients will not necessarily grow. Receivers may substitute the spillovers for their own R&D capital. In this paper the effects of spillovers on the demand for R&D capital by Canadian-owned firms and foreign affiliates are analyzed in an effort to determine whether R&D capital is a substitute for or complement to R&D spillovers. A policy implication of this result pertains to the relative efficacy of stimulating R&D expenditures between Canadian-owned and foreign-affiliate firms.

An analysis of spillovers and thereby of the social rates of return leads to the emergence of the concept of "strategic industry". In the context of R&D capital accumulation, strategic industries are those that have social rates of return exceeding their private returns. Thus, a strategic industry bestows benefits to R&D users beyond itself. Moreover, since the concept of strategic industry is tied to social rates of return, it is possible to rank strategic industries.

This paper is organized into several sections. First, the concept of R&D capital is discussed along with the determinants and the private rates of return to R&D capital in the United States, for Canadian-owned firms, and for foreign affiliates in Canada. The definition of R&D spillover is presented next, along with a discussion of the alternative ways in which this spillover has been measured and a summary of the findings on social rates of return. A specific examination of the spillover network estimated for Canadian industries follows, with a focus on the social rates of return for these industries and an analysis of returns, sources, and receivers of spillovers in the context of Canadian-owned firms and foreign affiliates. The final section is a conclusion.

DETERMINANTS AND PRIVATE RETURNS

FIRMS OPERATING IN DIVERSE INDUSTRIES hire factors of production and invest in new capital to develop new products and production processes. The development of new products and processes is part of a company's production activity. These activities involve inputs relating to various types of labour, physical capital and materials that are transformed into outputs.

Firms have an existing production set in which inputs are transformed into outputs. Some of the outputs relate to product and process development. These outputs are created from inputs that may be used simultaneously to produce many different outputs. (Such outputs do not necessarily pertain to product and process development.) In addition, some factors of production may be dedicated solely to the development of new products and processes. Hence, one need not think of product and process development as being carried out independently or separately from other production activities.

Multiple inputs are used in the creation of new products and processes. A feature of these inputs is that they do not become fully depreciated in a single period of production. In other words, these inputs are capital assets: scientists, engineers, technicians, laboratories, scientific equipment and materials and so forth. Essentially, the inputs relate to forms of human capital and physical capital used in the production of new products and processes. Indeed, the depreciation of these inputs relates to the depreciation of both human and physical capital stocks. These types of capital inputs are used in combination to alter product characteristics and production processes. Collectively, these inputs are referred to as R&D capital.

There are a number of issues associated with the accumulation of the R&D inputs. First, there are the costs of hiring the scientists, engineers and technicians, and the costs of building or renting laboratories. In addition, there are training costs of the labour inputs and the installation and development costs of the physical capital inputs — all required for developing new products and processes. Generally, these adjustment costs increase with the accumulation of the R&D inputs. In a sense, diminishing returns to the adjustment process arise from the introduction of new products and production processes.

Second, R&D capital accumulation causes firms to alter output and input proportions in existing production processes. Certain factors of production may be substituted, at least in part, for other inputs used in the more expensive and superseded process. There are many examples of unskilled labour being replaced by capital equipment. In addition, since firms generally produce multiple outputs, R&D capital expansion causes relative marginal costs to change. Firms increase the outputs that, as a result of R&D capital formation, have become relatively cheaper to produce and they decrease those that have become more expensive.

Third, R&D capital accumulation affects the product-demand conditions facing firms. Let us suppose that products deliver characteristics to consumers. For example, we demand mobility, reliability and style from automobiles. Automobiles are the products; mobility, reliability and style are the characteristics. If R&D capital expansion by a firm enhances the characteristics valued by customers (for example, through the use of microprocessors in cars), then demand will shift towards the product supplied by this firm.

These adjustment, expansion, substitution and differentiation effects associated with R&D capital are not specific to R&D capital accumulation but are associated with all forms of capital accumulation. Indeed, R&D inputs are capital inputs: they respond to changes in product and factor market conditions in a manner that is qualitatively similar to other capital factors of production.

The literature on the determinants of R&D capital has investigated the manner in which output supply, factor prices (e.g., those pertaining to labour) physical capital, intermediate inputs and R&D capital itself affect the demand for R&D capital. Bernstein and Nadiri (1989a) estimate models for four industries in the United States over the period 1959 - 1966 relating to output production using labour, physical, and R&D capital inputs. The last two factors of production are distinguished from labour because investment in both these stocks is subject to adjustment costs. Physical and R&D capital accumulation necessitate that producers incur purchase and adjustment (e.g., installation or development) costs. Adjustment costs imply that the capital stocks are less variable in the short run relative to the labour input.

Bernstein and Nadiri (1989a) find that, in the short run, when the capital stocks are inflexible a one percent increase in output growth causes labour demand to grow by 1.4 percent to 1.8 percent. However, as R&D and physical capital-adjustment costs are absorbed, the growth rates of output and labour become equalized. In the long run, as output grows, producers substitute R&D capital and physical capital for labour demand. This result is also obtained by Mohnen, Nadiri and Prucha (1986) for American, Japanese and German manufacturing sectors.

The effects of factor prices on the input demands provide further evidence of the relative inflexibility of R&D capital and the nature of factor substitution. Bernstein and Nadiri (1989a) estimate that a one percent increase in the wage rate decreases labour demand by 0.55 percent to 0.80 percent; increases by one percent in the factor prices of physical and R&D capital decrease their respective demands by 0.40 percent to 0.50 percent. Like other factors of production, R&D capital responds not only to its own price but also to changes in the prices of labour and physical capital. A one percent increase in the wage rate causes the demand for R&D capital to increase by 0.60 percent to 0.80 percent, while the same increase in the factor price of physical capital generates a decline in R&D capital demand by 0.10 percent to 0.35 percent. In sum, R&D capital is positively correlated with physical capital and negatively correlated with labour. In this sense, the capital stocks are complements of labour, and R&D capital is a substitute for it. (These results are similar to those obtained for the U.S. manufacturing sector by Mohnen, Nadiri and Prucha.)

Having established that the demand for R&D capital responds to output and factor price changes, we can turn to the next issue: how Canadian-owned firms behave relative to foreign affiliates. Bernstein (1984) investigates the determinants of the demand for R&D capital for 14 Canadian-owned firms and 15 foreign affiliates, and also analyses the parent firms, thus affording us a three-way comparison. The sample period is 1974 - 81. In Table 1 we see the R&D investment, R&D capital stock, and the R&D capital-to-output ratio for the

TABLE 1

R&D INVESTMENT, R&D CAPITAL, R&D CAPITAL-TO-OUTPUT RATIO FOR MAJOR R&D PERFORMERS

COUNTRY OF CONTROL	VARIABLE	MEAN	STANDARD DEVIATION	MIN.	MAX.
Canadian	R&D Investment*	3.963	4.520	0.187	21.346
	R&D Capital*	56.051	119.810	1.942	464.930
	R&D Capital/Output	0.106	0.067	0.021	0.299
Foreign	R&D Investment	9.392	17.397	0.400	79.506
	R&D Capital	79.277	134.170	1.304	488.250
	R&D Capital/Output	0.191	0.228	0.011	0.831

*Millions of 1972 dollars
SOURCE: Bernstein, 1984

Canadian-owned and foreign-affiliate major R&D performers. The mean R&D investment for affiliates is 2.5 times greater than for Canadian-owned firms, and the R&D capital stock for affiliates is 1.5 times the stock for Canadian-owned firms. Thus, in terms of R&D activity by major performers, affiliates are not less involved than their Canadian-owned counterparts. In fact, with respect to R&D intensity, affiliates have an R&D capital-to-output ratio twice the magnitude of Canadian-owned firms.

In the short run, a one percent increase in output causes the demand for R&D capital to increase by about 0.40 percent for Canadian-owned firms and by only 0.25 percent for the foreign affiliates. The demand for R&D capital by Canadian-owned firms is 50 percent relatively more responsive to output growth, and in this regard, the American parents behave very much like the Canadian-owned firms. The situation is quite different, however, with respect to physical capital. Here the foreign affiliates exhibit a demand in the short run that is four times more responsive to output growth than that found for Canadian-owned firms. Indeed, the demand for R&D capital by Canadian-owned firms is five times more sensitive to output growth relative to their own demand for physical capital. As output grows, the affiliates tend to vary their capital stocks in equal proportions. This result is also found for the parents, although they are somewhat more responsive than their affiliates.

In the long run, when adjustment costs have been fully absorbed all three classes of firms behave in the same manner and increase each input (including labour) in equal proportions to output growth. Even in the short run, each group treats labour demand in the same fashion. Thus, firms differ in their short-run behaviour with respect to the capital inputs.

Factor price changes affect the demand for R&D capital of Canadian-owned firms, foreign affiliates, and the parents. In the short run, a one percent increase in the factor price of R&D capital decreases the demand for R&D capital by 0.13 percent for Canadian-owned firms and by 0.21 percent for the foreign affiliates. Thus, with respect to the demand for R&D capital, Canadian-owned firms are significantly less price responsive relative to affiliates. Parent firms operating in the United States with a price effect of 0.28 percent, are even more responsive than their subsidiaries. In the long run, the degree of price responsiveness approximately doubles compared with the short run for each group of firms; their relative positions, however, do not change.

Changes in the wage rate and factor price of physical capital also affect the demand for R&D capital. Canadian-owned firms and foreign affiliates treat R&D and physical capital as complements, although the cross-price effects are very small. In addition, each class of firm substitutes R&D capital for labour. Moreover, as the wage rate rises, affiliates increase their demand for R&D capital by 33 percent more than Canadian-owned firms increase theirs. These qualitative results do not differ significantly between the short and long runs, although, in absolute value, the long-run price effects are twice the short-run magnitudes.

Differences between short- and long-run effects associated with output supply and factor price changes for foreign affiliates and Canadian-owned firms are partly attributable to the adjustment process for each group of firms. Adjustment costs are associated with the accumulation of physical and R&D capital and, as noted, they cause short-run inflexibilities in the demands for the capital inputs; these in turn also affect the magnitude of labour demand. An important aspect of an adjustment process is the speed by which the short-run magnitudes adjust to the long run. A result found in Bernstein (1984) is that 17.5 percent of R&D capital adjusts to its long-run magnitude within one year for both Canadian-owned firms and foreign affiliates. An imprecise translation of this finding is that it takes 5.7 years for each class of firms to adjust to its long-run R&D capital stocks. The parent firms take only 3.1 years to adjust. Thus, with respect to the R&D capital-adjustment process, there is no significant difference between Canadian-owned firms and foreign affiliates.

With respect to physical capital, affiliates take almost three years to adjust to their long-run magnitude, while Canadian-owned firms take almost five and one-half years to adjust. U.S. parents take almost three years to adjust. Hence, in terms of physical capital adjustment, affiliates and their parents behave in a similar fashion and also adjust faster than do Canadian-owned firms. Canadian-owned firms accumulate each of their capital stocks with the same adjustment speeds as do U.S. parents, although the latter exhibit relatively faster speeds of adjustment. Affiliates adjust their physical capital stock more quickly than they adjust their stock of R&D capital.

Adjustment costs, as well as influencing the manner in which factor prices and output supplies affect both the demand for R&D capital and the speed of R&D capital accumulation, help to determine the (marginal private) rate of return to R&D capital. The rate of return to R&D capital at the margin is defined as the profitability of an additional unit of R&D capital stock.

Marginal profit is often expressed as the cost reduction associated with additional R&D capital per dollar of R&D expenditure, and firms set their demand for R&D capital to the point where the marginal profit of R&D capital equals its respective marginal cost. Marginal cost consists of two components: the opportunity cost of funds and the marginal-adjustment cost per dollar of R&D expenditure. The opportunity cost of funds can be considered the cost of financing per dollar of R&D expenditure. Thus, the rate of return to R&D capital equals the opportunity cost of funds plus the marginal-adjustment cost per dollar of expenditure. It is often assumed that firms face a common opportunity cost of funds. (In a context with uncertainty, the opportunity cost of funds is replaced by the expected opportunity cost, so the assumption holds in expectation terms.) However, marginal-adjustment costs can differ across firms. In the long run, it is often assumed that marginal-adjustment cost is zero; therefore, rates of return to R&D capital are equalized across firms and, in turn, are equal to the (expected) opportunity cost of funds. In the short run, however, rates of return can differ among firms because marginal-adjustment costs differ.

Bernstein (1984) finds that for affiliates the rate of return on R&D capital is 17.4 percent compared with the return on physical capital of 13.7 percent. (The calculated rates of return, before tax and net of depreciation, are nominal.) The returns on capital stocks for Canadian-owned firms are not significantly different from one another: 18.1 percent for R&D capital and 17.8 percent for physical capital. Canadian-owned firms do, however, earn returns on physical capital that exceed those obtained by affiliates. In addition, the rates of return earned by U.S. parents are less than the rates found in Canada: the return on R&D capital is 13.9 percent; on physical capital the rate is 12.5 percent.

A significant policy implication associated with the determinants of the demand for R&D capital, along with its adjustment process, concerns the efficacy of tax policy. The Canadian government has a long history of using tax incentives to try to alleviate the problem of R&D underinvestment (see Bernstein, 1986). Tax credits increase the demand for R&D capital for two reasons. First, they reduce the factor price of R&D capital relative to other factors of production; thus, at given output levels, firms substitute R&D capital for other inputs. Second, tax credits reduce unit production costs; the reduction results in an increase in output supply and, to expand output, firms increase their demand for R&D capital. Clearly, in order to determine the magnitude of these two tax effects, it is necessary to know how the demand for R&D capital responds to changes in factor prices and output supply.

Bernstein (1984) looks at the effects of changes in tax policy on the demand for R&D capital by foreign affiliates and Canadian-owned firms. In the mid-1980s, for most firms the tax credit on R&D expenditures doubled, from 10 percent to 20 percent. In the short run, foreign affiliates increase their demand for R&D capital by 1.4 percent to 1.6 percent, and Canadian-owned firms increase theirs by 1.0 percent to 1.3 percent. In the long run, the percentage increase in the demand for R&D capital by the two firm groups are, respectively, 3.4 percent to 5.8 percent and 2.7 percent to 5.9 percent. In the short run, affiliates increase their demand only slightly more than do Canadian-owned firms, and in the long run any differences are negligible; although affiliates are significantly more factor price responsive, Canadian-owned firms are significantly more responsive to output-supply changes. Consequently, the two groups of firms are affected to a similar degree by changes in tax credits.

R&D SPILLOVERS AND RATES OF RETURN TO R&D

A DISTINCTIVE FEATURE OF R&D capital stock relates to the issue of appropriability. Firms that undertake R&D capital expansion may not be able to exclude other firms from freely obtaining the benefits of the R&D capital investment. Thus, the incentive to undertake R&D investment may be diminished because R&D-investing firms cannot prevent free riding and thereby cannot receive a sufficient return on investment. In this case, society will encounter an inadequate level of R&D capital stock.

As defined earlier, R&D spillovers are ideas freely borrowed by one firm from the knowledge of another. Spillovers can occur through input-output linkages in the economy. If an R&D-undertaking industry is an input supplier to a downstream industry, then spillovers can be generated by the upstream industry. If the price at which the input is purchased does not fully reflect the value of the additional R&D capital undertaken by the upstream industry, then a spillover exists.

Spillovers do not have to be related to input purchases; for example, developments in computer software occurred as a result of technological changes in hardware and network facilities. Spillovers can arise through various market and non-market transactions. They can occur by the use of innovations through cross-licensing agreements, and they can arise through the use of patents, since the royalty may not reflect the social value of the patent. The mobility of scientists and engineers generates spillovers to the extent that the knowledge held by these individuals is not firm-specific and the wage rate does not completely reflect the social value of these individuals. Revelations of trade secrets, of mergers and acquisitions, and of joint ventures also cause spillovers.

Spillovers are externalities. They exist only to the extent that market prices do not completely reflect the benefits from R&D capital formation. For example, when a firm purchases a machine, embodied in that machine is the R&D investment accumulated by the selling firm. Thus, R&D capital is part of the input requirements of the purchasing firm and is reflected in the market price of the machine. If the price fully reflects the benefits of the R&D capital, then no spillover has occurred. Conversely, if the price does not completely reflect the accumulated R&D investment, then spillovers exist.

Spillovers define the means by which firms can obtain the benefits of R&D capital accumulation undertaken by other firms in the economy. Consequently, spillovers create a wedge between the social and private rates of return to R&D capital. Private rates of return are those earned by the firms undertaking R&D capital formation. Social returns are defined as the private returns plus the benefits obtained by the free-riding firms using the R&D capital. Social returns relate to all the firms using the R&D capital, which could be an industry or a cluster of industries within a nation or group of nations.

In the investigation of the extent and effects of R&D spillovers, the pool of R&D spillovers or the pool of borrowed R&D has been defined in a number of ways. First, it has been defined as the sum of R&D expenditures of firms or of industries (see Griliches, 1964; Evenson and Kislev, 1973; Levin and Reiss, 1984, 1988). This approach implies that firms or industries are of equal importance in the generation of spillovers to other firms or industries in the economy. In addition, it assumes that spillovers are a contemporaneous phenomenon. In this approach past R&D expenditures do not generate spillovers.

As a second approach, the sum of R&D capital stocks of firms or industries is used to measure the spillover pool. This approach alleviates the criticism that spillovers arise only through contemporaneous investment. Nevertheless, firms or industries are still treated as equally important in the generation of spillovers (see Bernstein, 1988, and Bernstein and Nadiri, 1989b).

A third approach aggregates R&D expenditures or R&D capital stocks in some fashion. One weighting scheme relates to the proportion of the intermediate input or physical capital stock purchases from other industries (see Terleckyj 1974, 1980). In this case, it is assumed that the more one industry purchases from another, the more it can borrow its knowledge. Another weighting scheme uses patents to construct the pool of borrowed R&D. The patent weights have been classified by industry of origin and industries of use to form an inter-industry technology-flows matrix (see Scherer 1982, 1984; Griliches and Lichtenberg, 1984). Patent weights have been constructed according to a clustering technique to form a technology space (see Jaffe, 1986). Using patents to weigh R&D investment or capital assumes that firms are spillover sources only to the extent that new products or processes are patented.

A common feature of these alternative approaches is that the pool of borrowed R&D is defined as a single variable. Each spillover source is aggregated into a single pool. As an alternative to the aggregation of spillovers, Bernstein and Nadiri have introduced a fourth approach to the treatment of spillovers. They disaggregate borrowed R&D (see Bernstein and Nadiri, 1988; Bernstein, 1989; Bernstein and Nadiri, 1990) such that each producer is treated as a distinct potential spillover source. The spillovers arise from the R&D capital stocks of producers from anywhere in the economy (or, for that matter, from other economies). Producers do not have to be vertically linked through input purchases, horizontally linked by producing the same output, or even linked through patent uses.

A number of studies have measured the returns to R&D capital in the context of R&D spillovers. The majority of these have looked at inter-industry spillovers. Terleckyj (1974, 1980) evaluates R&D spillovers by using the input-output linkages in the economy. The pool of borrowed R&D of industry i is obtained by aggregating the R&D investment of all other industries in proportion to i's purchase of intermediate inputs from those industries. The rationale for this approach is based on the assumption that the more intermediate inputs i buys from j, the more i borrows R&D investment from industry j. Terleckyj (1974) investigates the effects of borrowed R&D investment-to-output ratios on total factor productivity growth. He estimates for 20 manufacturing industries in the United States over the period 1948 - 66 that the rate of return on borrowed R&D is 45 percent, while the return on own R&D capital is 12 percent. Thus, the social rate of return on R&D capital is 57 percent. Terleckyj (1980) in this more recent study finds results similar to those estimated in his earlier work.

In the Canadian context, Postner and Wesa (1983) investigate the effects of R&D spillovers using weights based on the direct and indirect intermediate input requirements. They estimate how own and borrowed intramural (in-house) and extramural (purchased) R&D capital growth rates affect labour productivity growth. They estimate the effects for 13 Canadian industries for the periods 1966 - 71 and 1971 - 76. Borrowed R&D capital is defined as indirect R&D capital, which is calculated as the total R&D capital minus direct R&D capital. Their results show that only indirect intramural R&D capital affects labour productivity growth, generating an 18 percent rate of return. (This percentage is also the social rate of return to R&D capital.) The difficulty with the Postner-Wesa study is that it evaluates the return on borrowed R&D capital only in terms of labour productivity and not with respect to total factor productivity. Moreover, in constructing their R&D capital stocks, in order to deflate R&D expenditures the authors use the price index for equipment and structures. Capital expenditures make up only 15 percent of total R&D expenditures, and so the price index for equipment and structures is an inappropriate deflator.

The first difficulty with using the input-output framework to evaluate the effects of R&D spillovers is that only forward linkages are captured in the analysis; spillovers from downstream to upstream industries are ruled out by the analysis. The second difficulty is that purchasing intermediate inputs may not be the way knowledge is dispersed in the economy. For example, computer- and telecommunication-manufacturing firms are not vertically linked, yet R&D capital investment in one can surely benefit the other.

Another way of evaluating inter-industry spillovers is to construct a technology-flow matrix based on patent data. Scherer (1982, 1984) constructs a matrix in which each patent is attributed to an origin industry and a few user industries that are likely to use the patent. This matrix transforms R&D investment by industry of origin to the various user industries. The approach assumes that the patent flow in the economy is the same as the benefits from the flow of R&D investment. Scherer uses 15 112 patents to form an 87 by 87 technology-flow matrix for U.S. firms in the year 1974. He finds, for 1964 - 78, that the combined effect on total factor productivity growth of own-process and borrowed R&D (which is product R&D) investment implies a rate of return of between 70 percent and 100 percent. The rate of return on own-product R&D investment is between zero percent and 40 percent. Thus, the social rate of return to R&D capital varies between 70 percent and 140 percent.

Griliches and Lichtenberg (1984) apply Scherer's procedure to 193 manufacturing industries in the United States over the period 1959 - 78. They estimate the effects of own-product, own-process, and borrowed R&D investment to sales ratios on total factor productivity growth. They find that own-process and borrowed R&D investment have the same effect on productivity growth. Together, these two elements generate a 40 percent to 65 percent rate of return on R&D capital, and the direct effect generates a 20 percent to 75 percent return. Thus, the social rate of return to R&D varies between 60 percent and 140 percent.

Rather than assign patents to use industries in order to develop a technology-flow matrix, Jaffe (1986) constructs a technology space, defined as a 49-dimensional space of patents. The pool of borrowed knowledge is a weighted sum of all firms' R&D expenditures. The weights are proportional to the firms' proximity in the technology space, and the proximity is measured as a correlation of firm positions in the space. Thus, Jaffe captures both intra-industry and inter-industry spillovers. He estimates that the social rate of return to R&D capital is 40 percent.

Using patent data to link the R&D investment of firms has limitations. First, not all firms patent the output from their R&D investment. Trade secrets are a substitute for patenting. Thus, using patents as a set of weights underestimates the quantity of new products and production processes. Second, R&D investment does not necessarily lead to successful inventions and thereby to patents. Third, patents cannot be used as weights without knowing the value of each patent. To use the number of patents as weights in constructing technology matrices or spaces implies that all patents are of equal value. Fourth, in building technology matrices or spaces there are arbitrary assignments of patents among industries. Patents are often assigned solely to the first, or immediate, user of the patent. Finally, since all the patents issued during the same year are used to form the current spillover pool, the accumulated effects of all the patents that were issued prior to the year in question are not included in the pool or otherwise taken into account in determining the weighting scheme to measure spillovers.

As has been discussed, one way to measure the pool of borrowed R&D is to evaluate each industry as a distinct R&D spillover source. Bernstein-Nadiri (1988) estimate R&D spillovers for five U.S. manufacturing industries over the period 1958 - 81. All potential spillovers are parameterized in the estimation model. Their results show that each industry is a receiver and most are senders of spillovers. The social rate of return varies from 11 percent to 111 percent and exceeds the private rate of return on R&D capital, which varies from 10 percent to 27 percent. The results show that the spillover network is such that spillover receivers are influenced by only a few sources and each source influences only a few industries.

Up to this point, the discussion has centred on the empirical results concerning inter-industry spillovers. Bernstein and Nadiri (1989) also estimate a model in which there are intra-industry spillovers associated with the R&D capital stocks. Firm level data are used, and the firms are grouped into four separate industries. The model is estimated for each group of firms over the period 1958 - 78. In each case there are significant spillovers, and the intra-industry social rates of return (net of depreciation) to R&D capital vary from nine percent to 16 percent, while the private rate of return is seven percent. Thus, in all the studies for both Canadian and American industries, the social rates of return exceed the private returns.

FIRM CONTROL AND R&D SPILLOVERS

THE FIRST ISSUE IN THIS SECTION concerns the effects of spillovers on receiving firms and industries; included in the discussion are the responses to spillovers by Canadian-owned firms and foreign affiliates.

The only paper that looks at the differential effects from R&D spillovers between the two groups of firms is Bernstein (1988). That study uses the sum of R&D capital stocks as the pool of borrowed R&D. Both intra-industry and inter-industry spillovers are analyzed; the data pertain to firms operating in seven two-digit Standard Industrial Classification Canadian industries over the period 1978 - 81: food and beverage; metal fabricating; aircraft and parts; electrical products; chemical products; pulp and paper; and non-electrical machinery.

The intra-industry spillover is found to be significant and leads to cost reductions. In the first five industries, Canadian-owned firms react differently to intra-industry R&D spillovers compared with foreign affiliates. In four of these industries, unit cost declines relatively more for affiliates than for Canadian-owned firms, with the unit cost reductions two and one-half to eight and one-half times greater for the affiliates. The food and beverage industry is the exception. Here, unit costs for Canadian-owned firms decrease by two and one-half times the magnitude for the affiliates. Thus, in four of the five industries where affiliates and Canadian-owned firms react differently to spillovers, affiliates benefit relatively more from intra-industry spillovers.

Intra-industry spillovers affect the demand for R&D capital of the receiving firms. Although spillovers transmit the benefits of R&D capital so that diffusion occurs, receivers can still substitute spillovers for their own R&D capital. In the majority of industries where affiliates benefit relatively more than their Canadian-owned counterparts, the demand for R&D capital increases as a result of the intra-industry spillovers. In aircraft and parts, electrical products, and chemical products, R&D capital is a complement to the intra-industry spillover. In the remaining four industries, firms substitute the freely obtained R&D capital for their own R&D capital. In the three industries that exhibit a complementary relationship a one percent increase in the intra-industry spillover generates a 0.40 percent to 0.55 percent increase in the demand for R&D capital. In the other four industries, the decrease in demand is 0.35 percent to 1.30 percent.

In fact, firms with relatively small propensities to spend on R&D (i.e., where R&D capital cost-to-total production cost ratios are small) tend to substitute intra-industry R&D spillovers for their own R&D capital. Firms with relatively larger R&D propensities treat intra-industry spillovers as complementary to their own demand for R&D capital. Moreover, it appears to be the case that firms with larger spending propensities operate in industries where foreign affiliates receive greater cost reductions (i.e., greater benefits) from intra-industry spillovers relative to Canadian-owned firms.

A policy implication from the results on intra-industry spillovers is that attempts to stimulate R&D spending can create greater dispersion among industries with respect to their R&D propensities. The reason is that relatively high R&D-spending industries will increase their R&D expenditures because of the direct effect of the government policy and the complementary effect from the ensuing growth in intra-industry spillovers. Relatively lower R&D-spending industries obtain the direct effect, but intra-industry spillover growth generated by government policy will dampen R&D spending because of the substitution effect. Moreover, given the intra-industry spillovers and the fact that Canadian-owned firms generally do not benefit from these spillovers by as much as affiliates do, it may be implied that policies aimed at increasing the R&D propensity of Canadian-owned relative to affiliates will, in general, fail.

Inter-industry spillovers generate larger cost reductions than do intra-industry spillovers. There are also no differences in cost reductions resulting from inter-industry spillovers between affiliates and Canadian-owned firms. The range of cost reductions is 0.50 percent to 1.10 percent. Firms also substitute inter-industry spillovers for their own demand for R&D capital. This result occurs irrespective of either firm control characteristics or R&D spending propensities.

The importance of the unit cost reductions arises from the fact that they are the productivity gains associated with the R&D spillovers. Consequently, these cost reductions represent the wedges between the private and social rates of return to R&D capital. The social rate of return to the R&D capital of firm i equals the private return plus the cost reductions bestowed on all other firms within the same industry as firm i plus the cost reductions on all other firms in the economy but not in the same industry as firm i. It is important to note that the social returns to R&D capital measure the benefit of an additional unit of an industry's R&D capital to the economy as a whole. There is no limitation on the calculation of the social return that firms be in the same industry; firms do

TABLE 2
CURRENT INTRAMURAL R&D EXPENDITURES AS A PERCENT OF SALES FOR 1987

INDUSTRY	COUNTRY OF CONTROL	
	CANADIAN	FOREIGN
Food, Beverage and Tobacco	0.1	0.7
Rubber and Plastic Products	1.4	0.3
Textiles	0.5	1.5
Wood	0.6	0.1
Pulp and Paper	0.3	0.1
Primary Metals (Ferrous)	0.3	0.3
Primary Metals (Non-ferrous)	1.3	0.6
Metal Fabricating	1.8	0.7
Machinery	4.0	1.6
Aircraft and Parts	13.1	19.1
Other Transportation Equipment	1.7	0.2
Telecommunication Equipment	17.1	15.5
Electronic Parts and Components	7.3	3.4
Other Electronic Equipment	25.1	8.4
Business Machines	12.9	2.9
Other Electrical Products	2.1	1.3
Non-metallic Mineral Products	0.3	0.5
Refined Petroleum and Coal Products	0.4	0.5
Drugs and Medicines	10.7	2.6
Other Chemical Products	1.6	1.1
Scientific and Professional Equipment	11.0	0.9
Other Manufacturing Industries	2.8	1.1
Gas and Oil Wells	0.6	0.4

SOURCE: Statistics Canada, Industrial Research and Development Statistics, 1987

not have to be vertically related through intermediate or physical capital input purchases, and they do not have to be related through patent uses.

The social rates of return equal the private rate plus the marginal-cost reductions due to the intra- and inter-industry spillovers. The net-of-depreciation social rates of return vary between 20 percent and 25 percent. The private rate of return is 11.5 percent and the majority of the wedge between the social and private returns consists of the cost reductions due to the intra-industry spillovers. The rates of return due to the intra-industry spillovers vary between 5.5 percent and 12.5 percent, while the returns due to the inter-industry spillovers vary between 1.7 percent and 2.3 percent. The significance of intra-industry spillovers in causing the social rates of return to exceed the private returns highlights the importance of foreign affiliates as receivers of intra-industry spillovers. With respect to intra-industry spillovers in metal fabricating, aircraft and parts, electrical products, or chemical products industries, the fact that the overall social return to R&D capital exceeds the private return

TABLE 3

NUMBER OF R&D PERFORMERS, 1987

INDUSTRY	COUNTRY OF CONTROL	
	CANADIAN	FOREIGN
Food, Beverage and Tobacco	130	26
Rubber and Plastic Products	62	12
Textiles	19	14
Wood	34	1
Pulp and Paper	24	9
Primary Metals (Ferrous)	11	3
Primary Metals (Non-ferrous)	11	2
Metal Fabricating	131	25
Machinery	224	30
Aircraft and Parts	10	7
Other Transportation Equipment	50	22
Telecommunication Equipment	16	8
Electronic Parts and Components	48	10
Other Electronic Equipment	78	15
Business Machines	62	9
Other Electrical Products	82	21
Non-metallic Mineral Products	28	6
Refined Petroleum and Coal Products	14	6
Drugs and Medicines	29	28
Other Chemical Products	103	64
Scientific and Professional Equipment	95	13
Other Manufacturing Industries	141	12
Gas and Oil Wells	15	9

SOURCE: Statistics Canada, Industrial Research and Development Statistics, 1987

owes more to foreign affiliates than to Canadian-owned firms. The converse result occurs for firms in the food and beverage industry. There are no differences between the two groups of firms operating in the pulp and paper and non-electrical machinery industry.

Up to this point in the section, the focus is on Canadian-owned firms and foreign affiliates as receivers of R&D spillovers. There are only two types of spillover sources: intra-industry and inter-industry; all firms in the economy are grouped into one of the two categories. In Bernstein (1989), industries are investigated as senders and receivers of spillovers, with each industry treated as a distinct spillover receiver and sender. Bernstein estimates a spillover network (an independently derived set of links in the economy) that characterizes a matrix of inter-industry spillover senders and receivers. This matrix is not constrained to input-output linkages, nor is it limited to links between patent sources and uses.

The inter-industry spillover network for nine Canadian industries is estimated over the period 1963 - 83. Industries are not distinguished by control

TABLE 4

DECOMPOSITION OF SOCIAL RATES OF RETURN

	RECEIVING INDUSTRY									SOCIAL R OF R
SOURCE INDUSTRY	PM	MF	OM	TR	EP	RP	PP	CP	GO	
Primary Metals		0.160								0.42
Metal Fabricating										0.29
Non-electrical Machinery	0.39			0.073	0.227			0.006		0.94
Transportation Equipment						0.002			0.010	0.29
Electrical Products										0.38
Rubber and Plastics			0.422						0.002	0.89
Petroleum Products	0.025		0.100		0.341					0.87
Chemical Products	0.031						0.526			0.81
Gas and Oil Wells			0.040							0.37

SOURCE: Bernstein, 1989

characteristics of their firms, since the data consist only of industry time series. Nevertheless, from Tables 2 and 3 it is possible to determine whether or not industries are foreign-affiliate intensive. (The definition of affiliate intensity is based on two features: a comparison of R&D expenditure-to-sales ratio between Canadian-owned and foreign-affiliate firms in an industry, and the number of affiliates relative to the total number of R&D performers in an industry.) If the relevant industries in Tables 2 and 3 are aggregated into the nine groups (used in the Bernstein study) listed in Table 4, then four of the nine industries are affiliate-intensive: transportation equipment, petroleum products, chemical products, and gas and oil wells.

The estimated spillover network in Table 4 shows that each of the nine industries is affected by inter-industry spillovers. Moreover, four of the nine industries are recipients of spillover-generated cost reductions from two or more industries. Seven of the nine industries are senders, with each source affecting a few industries and each recipient affected by a few industries. There are not more than three industries affecting any one recipient and not more than four industries affected by any one source. Thus, for any one sender or receiver the spillover network is relatively narrow. However, the collection of senders and receivers is not symmetrical, so the complete network involves most industries.

The social rate of return to R&D capital for any one industry consists of the private rate plus the cost reductions throughout the economy due to the spillovers generated by the industry's R&D capital. There are two components to the wedge between the social and private returns. The first component is the cost reduction bestowed on any one industry, and the second is the number of recipient industries. The combination of these two elements causes the social rates to exceed the private rates. For example, from Table 4, petroleum products generates cost reductions on three industries while rubber and plastics affects only two; yet the social rate of return is greater for rubber and plastics. It is therefore important to look at the social rate of return as a summary statistic depicting the significance of an industry in generating spillovers.

Within the context of R&D activities, a strategic industry can be defined as an industry whose social rate of return to R&D capital is relatively greater than the social rates from other industries. The phrase "relatively greater" is vague, but such imprecision is of no consequence because the social rates of return actually provide a ranking of industries. It is not necessary to cluster industries into strategic and nonstrategic categories. What is more appropriate is to think of industries in terms of a strategic ranking. From Table 4, the magnitudes of the social rates of return to R&D capital point out that non-electrical machinery, rubber and plastics, petroleum products, and chemical products are strategic industries. The social rates of return to R&D capital vary between 81 percent and 94 percent and exceed the private rates — which range between 24 percent and 47 percent (see Bernstein, 1989) — by 200 percent to 400 percent. Two of the strategic industries, petroleum products and chemical products, are affiliate intensive. The other two affiliate-intensive industries (transportation equipment, and gas and oil wells) have low social rates of return. Thus, in comparing affiliate-intensive industries with Canadian-owned industries, we have no reason to conclude that the former have relatively higher social returns to their R&D capital.

CONCLUSION

A NUMBER OF CONCLUSIONS are forthcoming from the analysis in this paper. First, R&D capital is the relevant input embedded in a general production process used to develop new products and processes. The determinants of R&D capital are similar to the determinants of other capital inputs: factor prices and output supplies affect the demand for it. The demand for R&D capital by Canadian-owned firms is less price responsive than is the demand for it by foreign affiliates. However, of the two groups, output growth triggers greater R&D capital expansion for Canadian-owned firms. This set of results implies that, of the two groups, Canadian-owned firms are more sensitive to business-cycle considerations in determining their R&D capital demands. Simultaneously, foreign affiliates are more influenced by changes in relative factor prices, such as the decline in computer prices. Tax policy operates through changes in factor prices and output supplies. The offsetting price and output responses of the demand for R&D capital cause the two groups of firms to react in the same manner to tax incentives designed to encourage R&D capital formation.

Second, in order for firms to accumulate R&D capital, adjustment costs must be incurred. Canadian-owned firms take approximately five and one-half years to adjust their stocks of R&D and physical capital to the long-run magnitudes. Foreign affiliates take five and one-half years to adjust their R&D capital stock but take only three years to adjust their stocks of physical capital. Differences in adjustment processes between the two groups of firms is reflected in physical capital and not in R&D capital. The implication for the adjustment process associated with incorporating new products and processes into production is that there are no differences between Canadian-owned firms and foreign affiliates.

Third, a distinctive feature of R&D capital accumulation is that R&D performers are unable to appropriate completely the returns from their R&D investment. Thus, firms are able to free ride and use R&D capital that they have obtained free of charge. This public-good aspect of R&D capital accumulation is referred to as R&D spillovers: a source of technology diffusion that is not necessarily linked to input-output flows or to sources and uses of patents. (R&D capital reflects the means by which spillovers are transmitted.) Spillover networks, which must be developed in their own right, show that receiving industries are influenced by only a few industries, and that sending industries influence only a few industries. However, because the networks are not symmetrical between senders and receivers, many industries are involved in the network. In order for us to evaluate the significance of R&D spillovers, we must compute the social rates of return to R&D capital. (The social rate is the rate of return to the use of R&D capital in society; the private rate is the return to the performance of R&D capital accumulation.) Studies dealing with American and Canadian firms and industries all show that the social rate of return is two to four times greater than the private rate. Therefore, there are significant spillovers associated with R&D capital formation.

Fourth, there are differences between Canadian-owned firms and affiliates as receivers of intra-industry spillovers. Spillover benefits evaluated in industries with relatively greater propensities to spend on R&D show that affiliates receive from two and one-half to eight and one-half times the benefits from intra-industry spillovers than their Canadian counterparts receive. In these industries, intra-industry spillovers cause the demand for R&D capital to expand. A complementary relationship exists between intra-industry spillovers and R&D capital, occurring in both Canadian-owned firms and foreign affiliates. However, in industries with relatively smaller spending propensities on R&D, intra-industry spillovers and R&D capital are substitutes. Thus, spillovers are not only a means of technology diffusion, but they also influence the demand for R&D capital.

Fifth, strategic industries are defined according to the social rates of returns to their R&D capital stocks. The reason is that the difference between the social and private returns to R&D capital signify under- or overinvestment in R&D. If the social return from an industry's R&D capital exceeds the private return, then one sees underinvestment in R&D and potential gains to society from increasing R&D investment in that industry. In Canada, preliminary analysis shows that there are four strategic industries: non-electrical machinery, rubber and plastics, chemical products, and petroleum products. The social rates of return vary between 81 percent and 94 percent and are two to four times greater than the private rates of return. Although two of the four industries — chemical products and petroleum products — are foreign affiliate-intensive, strategic industries can arise from those that are relatively intensive in either Canadian-owned firms or foreign affiliates.

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DISCUSSANT'S COMMENT

DISCUSSANT:
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THIS PAPER REVIEWS the valuable research undertaken by Jeffrey Bernstein in the area of R&D and science policy in Canada, with a special focus on the role of foreign affiliates.

Given my own affinity with his research methods I have little to quarrel with in this paper. There is, however, one point on which the author and I are a bit at odds — his view on the use of supporting matrices, especially the patent flows matrix to aggregate outside R&D. Various supporting matrices are available to measure the proximity between R&D performers. One can use intermediate input flows, patent flows, correlations of position vectors in a technology space, and, I would add in passing, innovation flows as employed recently in an econometric study by Sterlacchini (1989).[1] Each of these measures has its drawbacks and I fully agree with the author as to the weakness of patent data as R&D outputs. I want to point out, however, that the vectorization method he proposes is not flawless either. For instance, the argument of the correct lag between R&D performances and effects does apply equally here. I would therefore argue that each approach is worth exploring, and that it would be beneficial to compare the results of different approaches rather than to pick one outright and reject the others. For the remainder, I would like to mention three generalizing extensions that could be pursued within this rich framework.

First, to estimate the rate of return, both the cost and the demand effects could be taken into consideration. Not only does R&D shift the average cost curve downwards, it also shifts the demand curve to the right. I know Professor Bernstein is now engaged in this attempt.

Second, most of the present work on inter-industry spillovers is restricted to the manufacturing sectors. Consequently, the social rates of return on R&D in the paper are underestimated as there are more than nine sectors in the economy and, hence, additional receiving sectors. In this regard, it would be worth looking into the spillovers emanating from the service sectors (e.g. the software services).

Third, little work has been done on the subject of international R&D spillovers. This links with Magnus Blomström's paper. In a recent work for the Economic Council of Canada, I estimate that the Canadian manufacturing sector as a whole earns an immediate rate of return from foreign R&D that is three times as large as the rate of return on domestic R&D.

Professor Bernstein and I are planning to examine this issue at a more disaggregate level of 2-digit industries or firm data: by how much do Canadian firms benefit from foreign R&D and vice versa? This also calls for some more theoretical thinking about how to define an international social rate of return on R&D. The benefits from domestic R&D might leak out as foreign firms see the costs go down. This, however, might not be altogether bad for the Canadian economy, as other Canadian firms might, as a result, buy their inputs from abroad at a lower price. R&D is more and more conducted at a global level. This aspect calls for more modelling of the international flows of externalities, and estimating of their magnitudes, and their incorporation into the elaboration of science policies.

Endnote

1. Sterlacchini. "R&D, Innovations and Total Factor Productivity Growth in British Manufacturing", *Applied Economics*, 1990.

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6

Multinational Responses to Trade and Technology Changes: Implications for Canada

INTRODUCTION

THE 1980S HAVE BEEN CHARACTERIZED by enormous changes in the economic, social and political environments, both national and international, facing multinational enterprises (MNEs) in North America. How have MNEs responded, and how are they likely to respond in the 1990s?

This paper focusses on four major changes in the business environment — two in technology and two related to trade policy — that are, in turn, changing the way MNEs make their organizational and location decisions. The technological changes are in information technology (IT) and process technology, specifically, the development of just-in-time (JIT) manufacturing. The changes in the trade policy environment derive from the 1989 Canada-U.S. Free Trade Agreement (FTA), and the prospect of a North American Free Trade Agreement (NAFTA) among Mexico, Canada and the United States.[1]

Technology is changing the playing field on which firms compete; trade policy is changing the rules of the game.[2] In examining the effects of these changes we are interested in the likely responses of American multinationals with Canadian subsidiaries, given current MNE locational patterns and organizational structures. The changing locational and organizational structures of Canadian manufacturing affiliates are of particular interest in manufacturing since this is where the technological changes are advancing most rapidly. Much has been written on the subject of strategic management of multinationals, technological change, globalization, and economic integration, yet few researchers have considered these together with a view to analyzing the likely impacts of technological and economic integration changes on MNE locational and organizational decisions within North America.[3] This paper is intended to provide such a conceptual framework and offer some predictions based on that framework concerning multinational responses to change.

The paper has four parts. Following the introduction, above, I develop a framework for the discussion based on the value chain, which determines the organizational and locational patterns of MNEs. This framework is then applied to American multinationals operating in North America in the 1970s. I then outline four changes — two in technology and two in trade policy — currently affecting MNEs. There follows an analysis of the organizational and locational responses of American MNEs in the 1980s and their likely responses in the 1990s, focussing particularly on the implications of these responses for their Canadian affiliates. Finally, I offer my conclusions.

MNE ORGANIZATIONAL AND LOCATIONAL PATTERNS

A FRAMEWORK FOR UNDERSTANDING MNE RESPONSES TO CHANGE

MULTINATIONAL ENTERPRISES are firms that control and organize production establishments (plants) located in two or more countries. For over a century the basic method of MNE expansion into overseas markets has been through foreign direct investment (FDI).[4] In order to explain the organizational structure of MNEs and the locational patterns of MNE production and intra-firm trade flows, it is necessary to have a conceptual framework that explains the existence and growth of multinationals. Dunning's (1981, 1988) eclectic or Ownership-Location-Internalization (OLI) model of FDI is appropriate in this connection. I also assume that MNEs form and grow because of three factors; each involves simultaneous decisions for the parent firm.[5]

1) Ownership advantages: MNEs have intangible ownership or firm-specific advantages (FSAs) from which they can earn rents in foreign locations and which allow them to overcome the cost disadvantage of producing in foreign markets. Such ownership advantages or core competencies are usually knowledge- or oligopoly-based, and can be transferred within the MNE at relatively little cost. Knowledge-based advantages include product and process innovations; oligopoly-based advantages include economies of scale and scope, and privileged access to raw materials or financing. FSAs are not fixed for the firm; core competencies require identification and continuous investment to prevent their dissipation and/or obsolescence.[6]

2) Internalization advantages: These depend on the relative costs and benefits of alternative contractual methods for supplying foreign markets. It is normally more profitable for MNEs to earn rents on their FSAs and to service foreign markets through subsidiaries than by exporting or by other contractual arrangements because of exogenous market imperfections confronting these MNEs along with the oligopolistic motives MNEs have for internalizing external markets. Exogenous market imperfections include both natural imperfections, such as transactions costs which impede trade, and government-imposed imperfections, such as tariffs, exchange controls, and subsidies. Endogenous or oligopolistic imperfections include exertion of monopoly power, cross-subsidization of markets and opportunistic exploitation of suppliers or buyers. Internalization helps prevent the dissipation of, and increases the rents from, the core competencies of the MNE.

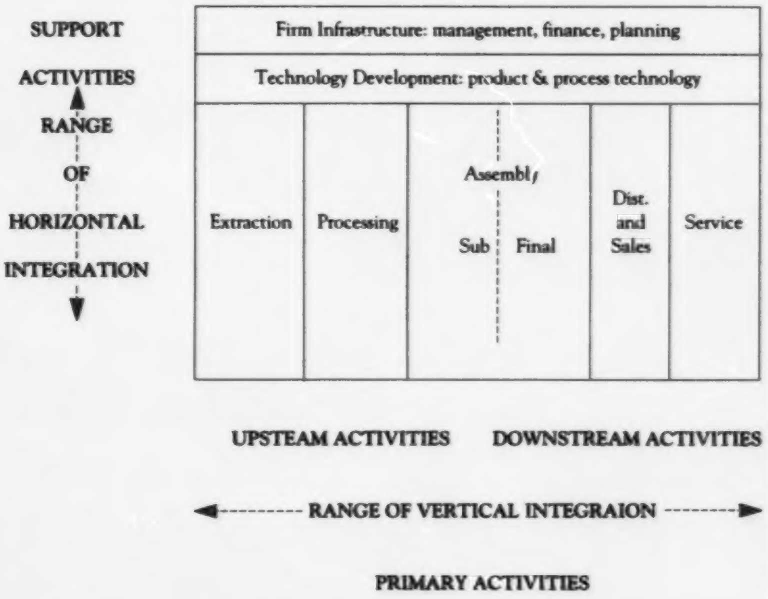
3) Locational advantages: FSAs must be used in combination with immobile factors in foreign countries to induce FDI. Country-specific advantages (CSAs) determine which countries will host MNE foreign production. CSAs can be broken into three categories: economic, social and political (the ESP factors), which change over time. Economic CSAs are based on a country's factor endowments of labour, capital, technology, management skills and natural resources. In addition, market size, transportation and communications can make a host location more or less economically attractive. Noneconomic or social CSAs include the psychic distance between countries in terms of language, culture, ethnicity, and business customs. Political CSAs include general host-government attitudes towards foreign MNEs and specific policies that affect FDI and foreign production, such as trade barriers and investment regulations. FDI is therefore likely to be attracted to those countries that are geographically close and have similar incomes and tastes to the home country, and have good factor endowments and low factor costs.

These OLI advantages determine the organizational structure and locational patterns of MNEs in the following manner. As in Porter (1986, 1987), we assume multinationals are engaged in a range of activities, the "value chain", consisting of primary activities (functions involving the physical creation of the product) and support activities (functions that provide the intangible assets and infrastructure necessary to support the primary activities).[7] Figure 1 shows a hypothetical value chain of a manufacturing MNE. Six primary activities are identified which are part of the firm's value chain: upstream activities including extraction of raw materials, processing, and sub-assembly, and downstream activities including final assembly, distribution and sales, and service. We focus on two support activities: firm infrastructure, and product and process technology development.

The MNE's range of activities determines its competitive scope. Competitive scope is important because it determines the degree of horizontal and vertical integration practised by the MNE, and these influence the MNE's organizational and locational structures. Porter (1986, p.22) defines four types of competitive scope: segment scope (number of product varieties, customer types), industry scope (range of industries in which the MNE competes), vertical scope (which primary activities are part of the firm's value chain as opposed to being produced by other firms), and geographic scope (number and types of countries in which the MNE is active).

A horizontally integrated MNE produces the same product in two or more plants located in different countries; i.e. one of the primary activities, such as the processing of raw materials, occurs in two or more locations. The degree of horizontal integration is roughly represented in Figure 1 by the number of

FIGURE 1
THE VALUE CHAIN


SUPPORT
ACTIVITIES
RANGE
OF
HORIZONTAL
INTEGRATION
Firm Infrastructure: management, finance, planning
Technology Development: product & process technology
Extraction
Processing
Assembly
Sub
Final
Dist. and Sales
Service
UPSTEAM ACTIVITIES
DOWNSTREAM ACTIVITIES
RANGE OF VERTICAL INTEGRAION
PRIMARY ACTIVITIES

countries in which the MNE is active in any one primary activity. The motivation for horizontal integration is the additional rents in the foreign location that can be earned by the MNE's firm-specific assets (Caves, 1982; Eden, 1989b, Grimwade, 1989). Assuming that a technology, once produced, can be transferred at minimal cost within an MNE, that MNE can increase its global profitability by applying technological advantages with respect to its products and processes in new locations. Horizontal integration usually occurs at the final assembly and sales stages with market-driven manufacturing MNEs because governments encourage foreign firms to produce locally and to be nationally responsive. However, resource-based multinationals may have one or several raw material plants depending on plant economies of scale relative to the size of the MNE's global market. (For example, one chemicals plant can supply the world market for a drug MNE, whereas an aluminum firm is likely to have several bauxite plants).

A vertically integrated MNE controls and coordinates two or more primary activities. The degree of vertical integration is determined by the number of primary activities in the firm's value chain in Figure 1. The motivation for vertical integration is to avoid transactions and governmental costs associated with external markets. Uncertainty and incomplete futures markets combine to raise barriers to contract-making between unrelated firms, particularly in natural resource industries and industries where quality control is essential (Casson, 1982, 1986; Porter, 1986; Grimwade, 1989). Government barriers can be avoided through techniques such as transfer pricing of intra-firm trade, and leading and lagging financial flows (Eden, 1990b, 1985).

MNE Locational Strategies

In the general OLI framework, the FSAs of a multinational enterprise give the MNE advantages over domestic firms when it goes abroad. The advantages of internalization imply that the MNE can best profit from its FSAs through a hierarchy of vertical and horizontal intra-firm linkages. However, neither of these factors determines where the MNE invests.

Location tends to follow strategy; i.e. the particular location selected by an MNE depends on the strategic role its affiliate is expected to play within the value chain. MNEs go abroad to access low-cost foreign inputs (including natural resources and technology), to be close to foreign markets, to earn rents on their technological FSAs, and to pre-empt competition. Of these, the most important reasons for FDI probably are sourcing natural resources, reducing costs, and accessing foreign markets. Thus the primary purpose of FDI is foreign production, and the locational decisions about production will determine FDI flows (Cantwell, 1988). Both horizontal and vertical FDI have generated substantial growth in intra-firm trade flows in the post-war period (Grimwade, 1989, pp. 143-215; McCulloch, 1985; Rugman, 1985).

Locational or country-specific advantages (CSAs) are the key to determining which countries will become host countries for an MNE, depending on whether the motivation behind its investment is resource seeking, cost reduction, or market access. In the light of these three locational strategies for FDI, I contend that multinationals build their overall production structure by choosing from among the following factory types for their foreign affiliates:[8]

1) Resource-based FDI

Extractors access natural resources that are essential to the production process. The key factor driving location with respect to such activity is the need to be close to the source of raw materials. Depending on resource stocks and economies of scale, one extractor plant may or may not be sufficient to supply the entire MNE.

Processors process raw materials and turn them into fabricated materials. The processing stage can in turn be further divided into refineries, smelters and fabricators. Extracting and processing may occur in the same plant when the weight-value ratio is high, economies of scale at the two stages are similar, and foreign tariffs on processed imports are not high.

2) Cost-reducing FDI

Offshore factories tend to use cheap local inputs, particularly labour, to produce components or to assemble products for the parent company. Many American MNE investments in the newly industrializing economies (NIEs) in Asia and the Mexican maquiladoras are of this type. As wage rates rise in the NIEs, such offshore factories move from country to country in search of sites with low wage rates,

Source factories are a step up from offshore factories. Source plants provide access to low-cost inputs, but they also carry responsibility for the development and production of specific components for the MNE. Source factories are globally rationalized plants where the rationalization is vertical; i.e. the factory produces one segment of the value chain. Source factories contribute to the MNEs by producing subcomponents for final assembly and sale elsewhere. Depending on economies of scale, there may be one or several plants producing the same components. The source factory is tightly integrated into the MNE network since its production is intended wholly for intra-firm sale.[9]

3) Market-driven FDI

Importers or distributors provide marketing, sales, service and warehousing facilities. Usually, when a firm establishes a subsidiary abroad, its first step is to set up as an importer plant to facilitate exports from the parent firm.

Local Servers are import-competing factories designed to service local markets. They often assemble subcomponents for domestic sale (e.g. bottling plants, drug packaging). Such assembly is often driven by government regulations requiring a local presence; local production may also increase domestic sales.

Focussed factories are globally rationalized subsidiaries in a horizontal sense: i.e. they produce one or two product lines in mass production runs for final sale in both local and foreign markets; the remaining product lines are supplied from other affiliates. Thus, within the final assembly and sales stage of the value chain, the MNE may rationalize production by allocating product lines to specific affiliates and encouraging horizontal intra-firm trade of these product lines. Such affiliates are relatively autonomous and are often nationally responsive units with some R&D facility, mostly in process technology.

Miniature replicas are plants, protected by high tariff barriers, that assemble and sell a full line of products, similar to that of the parent, in the local market. Such affiliates are likely to be high cost if domestic markets are small. In such circumstances it is difficult for them to exploit economies of scale. Miniature replicas were the most common form of market-driven affiliate in the Canadian manufacturing sector prior to the reduction of tariff barriers under the Tokyo Round and the introduction of the Auto Pact in 1965.

World product mandates (WPMs) are plants with full responsibility for the technological development, production and global sales of a single product line within the MNE. The WPM represents a specific strategy quite distinct from the focussed factory. Although both manufacture product lines for global sale, the WPM is responsible for product design/redesign for its own output. In the case of the focussed factory, comparable responsibility rests with the parent. WPMs entail close cooperation between parent and affiliate, and require larger product innovation capabilities than focussed factories.[10]

Lead factories are equal partners with the parent firm and within the framework of an MNE are often treated as a separate division. Lead factories occupy strategic locations within each Triad bloc (North America, Europe and Asia) and are responsible for both technology and product creation and distribution. Lead factories also have true insider status in each of their major locations.

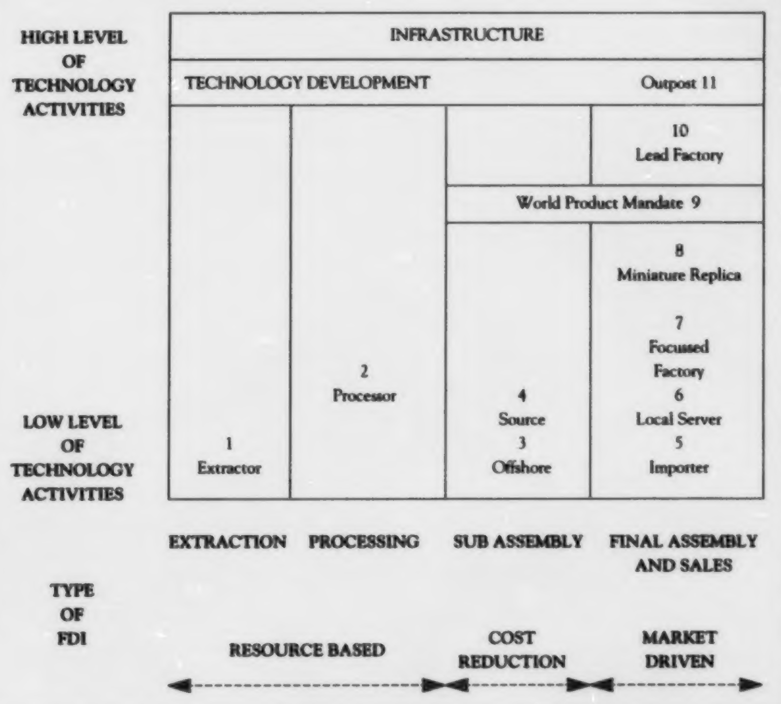
Outposts are R&D-intensive plants set up in foreign markets primarily to collect information for the MNE. The purpose of these plants is to source knowledge worldwide and to act as a window on technology developments in other countries. Usually these are brownfield acquisitions or joint ventures with established firms or universities.[11]

The taxonomy for the above is illustrated in Figure 2, which shows each factory type in its relevant part of the value chain. The higher the placement of the factory, the greater the amount of technological innovation expected from the subsidiary. Each MNE, depending on the length of its value chain and the nature of its industry, consists of a head office and a set of foreign affiliates, each strategically located according to its underlying resource, cost or market function. For example, automotive MNEs typically consist of offshore and source factories in the NIEs (which produce parts and component assemblies), local servers (which assemble completely knocked down kits in LDCs), and focussed factories in OECD countries (which assemble and distribute certain product lines while importing others).

Figure 2 implies that every subsidiary has a primary role. It should also be clear, however, that an affiliate can occupy more than one strategic position within an MNE at the same time (e.g. a world product mandate along with a contributor role). Depending on the nature of the industry (globalized, government-controlled or mixed-structure) MNEs are more-or-less likely to choose particular locational strategies. As Doz (1986) shows, in mature, global industries such as automobile manufacturing, multinationals tend to use integrative, cost-driven strategies using offshores and local server factories to divide the production process among their affiliates and subcontractors, then assemble locally to meet domestic content requirements. Conversely, government-controlled industries such as telecommunications and aircraft manufacturing tend to adopt more nationally responsive strategies such as miniature replicas and focussed factories.

FIGURE 2

AFFILIATE ROLES WITHIN THE MNE


HIGH LEVEL OF TECHNOLOGY ACTIVITIES
INFRASTRUCTURE
TECHNOLOGY DEVELOPMENT
Outpost 11
10 Lead Factory
World Product Mandate 9
8 Miniature Replica
7 Focussed Factory
2 Processor
4 Source
6 Local Server
LOW LEVEL OF TECHNOLOGY ACTIVITIES
1 Extractor
3 Offshore
5 Importer
EXTRACTION
PROCESSING
SUB ASSEMBLY
FINAL ASSEMBLY AND SALES
TYPE OF FDI
RESOURCE BASED
COST REDUCTION
MARKET DRIVEN

The strategy adopted in choosing a new location also depends on the age of the affiliate. I contend, following Ferdows (1989), that new factories are usually extractors, offshores or importers, depending on their strategic function within the MNE (resource-, cost-, or market-based). The strategic function of a plant may change over time; as it grows and matures it may develop the capabilities to undertake new functions. If the subsidiary is allowed relative autonomy to develop within the MNE, such growth in function(s) is more likely. Therefore, as the foreign affiliates mature, extractors may take on processing functions, offshores may become source factories, and importers may become local servers.

Whether such upgrading of affiliates occurs depends on the economic, social and political factors outlined earlier. For example, a high effective rate of protection in the home country deters local processing and encourages exports to the parent firm for processing (e.g. Canadian logs exported to the United States for processing into lumber). As wage rates rise over time in the NIEs there may be an incentive to shut down offshore plants and move the footloose production to cheaper labour sites rather than upgrade the plant to a source factory. The growth pattern of demand-driven factories may be the most interesting, in view of the number of opportunities that are open to them (e.g. importer, focussed factory, world product mandate, lead factory). Clearly, the relative size and strength of the local market, the level of trade barriers, capital and labour costs, and government regulations and incentives for R&D can all affect the choice made by the MNE. Given the simple cost-reduction function of offshores and sources, I suggest that these types of factories are unlikely to become lead factories. Processors and focussed factories, however, may take on the functions of full lead factories if they occupy a strategic location within one of the Triads.

MNE Organizational Strategies

The organizational structure of MNEs encompasses two components: legal organization and managerial organization (Robock and Simmonds, 1989, p. 253). The legal organization defines the ownership arrangements between the parent company and its affiliates (e.g. branch, subsidiary, joint venture, strategic partnership, etc.). The traditional foreign affiliate is a wholly-owned subsidiary within which contractual and other trading arrangements are carried out at *non*-arm's-length. However, MNEs also use other devices, such as subcontracting, joint ventures and licensing arrangements, to organize production, particularly if host country regulations require local participation. The wholly-owned subsidiary is generally preferred as an organizational form in order to protect the MNE's firm-specific advantages (Eden, 1989b).

The managerial organization determines executive lines of authority and responsibility, lines of communication, information flows and how they are channelled and processed. *Business International* (1988, pp. 113-19) identifies seven types of MNE international managerial structures: international, regional, national subsidiary, product, functional, matrix and mixed. Each is described briefly below:

1) *International Division* One unit within an MNE with responsibility for all international operations. This is a common structure for new MNEs, and is used widely by Japanese and Asian multinationals.

2) *Worldwide Regional* Each affiliate is responsible for a specific territory or regional division; the home market may be a division like the others. This structure is used by American MNEs with mature, standardized products where marketing and service are important; e.g. beverages, cosmetics, petroleum, with the affiliate being responsible for a region such as South America or Asia.

3) *National Subsidiary* This format is similar to the regional structure but is more decentralized since each country constitutes a division. European MNEs typically used this structure, the so-called "mother-daughter" structure.

4) *Worldwide Product* The MNE is organized into several domestic businesses each of which is responsible for its own worldwide operations. This structure is used by MNEs that need to coordinate upstream activities centrally and to integrate technological development, production and markets for each product horizontally.

5) *Worldwide Functional* Divisions are determined by the MNE's major functions, e.g. administration, manufacturing, R&D. This structure is not employed as much as others, but can be found in mining and steel and in small, international companies with an integrated product line.

6) *Matrix and Matrix Overlay* In a matrix structure, the MNE focusses on two characteristics (product, function, region), giving a dual chain of command and encouraging cooperation across characteristics. The most common is dual reporting to the head office by the product and regional divisions. Given the complexity of managing a matrix structure, most MNEs have moved to a Matrix Overlay structure where one element (e.g. region) is emphasized and the other two are monitored.

7) *Mixed* This organizational structure combines two or more of the above structures (e.g. an international division, a few worldwide product divisions and some national subsidiaries). This structure is useful for large MNEs where individual affiliates require different structures.

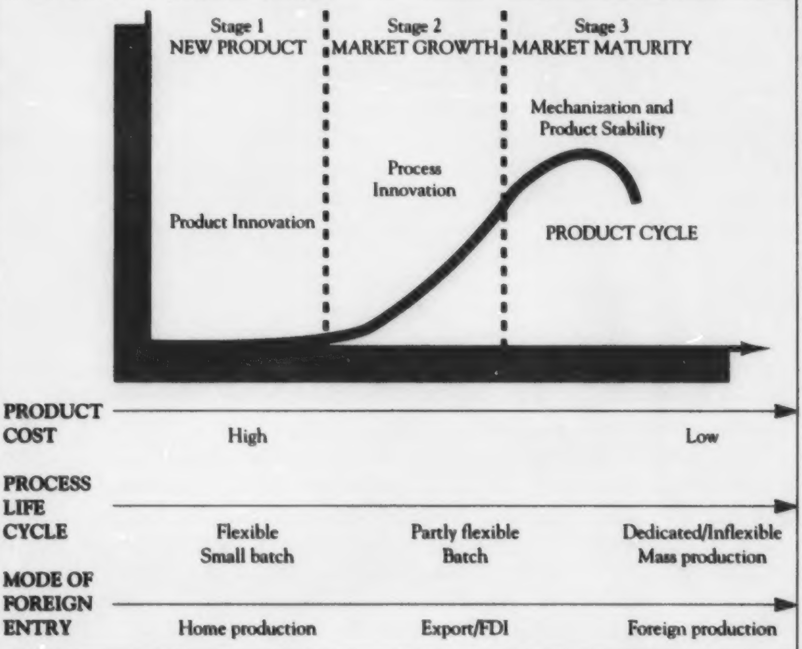
The choice among these managerial structures depends partly on corporate strategy. As the need for global strategic planning increases, MNEs adopt more global organizational structures to facilitate the integration of national and international planning. The more integrated the structure, the less the local autonomy of the affiliate and the greater the centralization and coordination functions of the parent firm.

Managerial structure also reflects the degree of internalization of the MNE; i.e. the MNE's relative shares of international versus domestic sales (Robock and Simmonds, 1989, p. 255; OECD, 1987, pp. 43-6). Assuming that the purpose of moving outside the domestic situation is market-driven, a firm may first set up an importer unit abroad; as exports increase, it may then set up a managerial export department within the head office to organize international sales. Sales, service and warehousing operations go abroad next. Once foreign production has been established, the MNE may set up largely autonomous miniature replicas. An international division within the hierarchy is usually established once the degree of internationalization reaches some acceptable minimum. At the global stage, the organizational structure is usually re-defined along functional, regional or product lines.

These organizational stages can be grouped into two basic groups: domestic structures (organized along functional or divisional lines) and international structures (e.g. autonomous subsidiary, international division); these corre-

FIGURE 3

PRODUCT AND PROCESS LIFE CYCLES


Stage 1
NEW PRODUCT
Stage 2
MARKET GROWTH
Stage 3
MARKET MATURITY
Mechanization and Product Stability
Process Innovation
Product Innovation
PRODUCT CYCLE
PRODUCT COST
High
Low
PROCESS LIFE CYCLE
Flexible
Small batch
Partly flexible
Batch
Dedicated/Inflexible
Mass production
MODE OF FOREIGN ENTRY
Home production
Export/FDI
Foreign production

Source: adapted from Goldhar (1989, p. 260)

spond roughly to the degree of maturity of the multinational. Firms generally progress from domestic to global structures as the percentage of foreign sales in relation to total sales rises.[12]

In the following section, I briefly review the history of American MNE development and identify the changing strategic functions of American affiliates, using the locational and organizational frameworks developed above.

A Brief History of MNE Locational and Organizational Strategies

Production processes in manufacturing firms can be classified under four headings: continuous flow, assembly line, batch, and jobbing to project. According to this progression, jobbing to project is the most flexible, and continuous flow is the least flexible (Easton and Rothschild, 1987, p. 303). The choice of production process is determined partly by the product life cycle. The traditional manufacturing process is based on the concept of products moving from introduction to maturity to obsolescence. New products require frequent design and process changes, the production process is unstandardized and most likely to be project- or job-based. As products become more mature the increase in volume requires a standardization of product design and a shift from labour-intensive to capital-intensive operations. Eventually, assembly lines and continuous flows generate significant economies of scale (EOS) from the mass production of standardized products. Flexibility is, consequently, reduced and response time is slowed but the average cost per unit falls.

As Figure 3 shows, when a new product is introduced it is normally produced in small batches with flexible technologies. As the product moves through its life cycle, product innovation is replaced by process innovation. Once economies of scale have been exploited domestically, the product is normally moved abroad to be produced by affiliates of the MNE. Cost competition through mass production becomes increasingly important such that mature products are often produced in low-wage countries.

In the early 1900s manufacturing firms in the United States began to mass produce consumer durables for their domestic markets. MNEs expanded by exploiting economies of scale and scope in extraction, production and distribution first at home and then abroad (Chandler, 1986, 1990a,b). Mass production industries developed which were capital-intensive, permitting large economies of scale at the plant level. Capital-intensive plants normally used either continuous-flow or assembly-line technologies, allowing production at substantially lower cost than labour-intensive, batch or job processes in small plants. However, the cost advantage of mass production, as Chandler (1986, 1990a,b) stresses, depended on throughput. Throughput required coordination of inputs and outputs and thus a managerial hierarchy. Economies of scale at the plant level, therefore, depended on both technological and organizational inputs.

In the post-1945 period, globalization, defined as high interdependence between national markets, proceeded rapidly with domestic firms facing new competitors at home and abroad. American multinationals set up miniature replicas in Canada and in Europe, designed to supply local markets behind relatively high tariff walls. New products were produced first in the United States, then moved abroad as the American market became saturated and international demand increased. Major natural-resource-seeking investments were made to set up extraction plants, particularly in Canada in the mining and petroleum sectors. Some of these plants did their own refining (e.g. petroleum); others exported raw materials for processing in the United States (iron ore to steel plants).

Post-war expansion, based on global investments by MNEs in the automotive and petrochemical sectors and government investments in infrastructure, had run its course by the late 1960s (Van Tulder and Junne, 1988). Globalization was encouraged by technological advances in transportation and communications, liberalization of exchange rate and credit policies, tariff reductions under GATT rounds, and the increasing integration of capital markets. By 1970, western European firms had emerged as strong competitors and Japanese firms were starting to export high-tech manufactured goods. During the 1970s, European MNEs began to invest in the United States and intra-industry FDI began to replace the inter-industry FDI characteristic of the pre-1970 period. Intra-industry trade and horizontally integrated intra-firm trade between OECD countries increased rapidly (Grimwade, 1989). The 1970s energy squeeze, lagging productivity, stagflation, and the rise of the newly industrialized economies increased the competitive pressures placed on American firms.

From the late 1960s through the 1980s, American multinationals responded to this new competition with four organizational and locational strategies. The first strategy was to extend the value chain through mergers and acquisitions. A wave of mergers forming conglomerates able to control forward and backward linkages, reduce risk and cartelize local markets occurred during the late 1960s (many of which subsequently collapsed, see Chandler 1990a).

The second strategy was to automate production, increase plant size and rationalize plants (creating focussed factories under horizontal rationalization, and source factories under vertical rationalization) to achieve greater economies of scale. The automotive industry is a good example of an industry that globalized and rationalized during this period. Specifically, the signing of the 1965 Auto Pact encouraged the phasing out of miniature replicas in the auto industry and their replacement by focussed factories. In the late 1970s the Ford Motor Company attempted to build a world car, locating world-scale source plants in low-cost locations. However, the necessary economies of scale were not achieved and the attempt was aborted.

The third strategy was to move production offshore to the NIEs and to the Mexican maquiladoras. These offshore plants were designed to lower overall costs to the MNEs by shifting production and subassembly to developing countries with lower unit labour costs. U.S. tariff legislation (sections 806 and 807) encouraged the move to offshore assembly factories by making the relevant U.S. tariffs applicable only to the foreign value added. Intra-industry trade in intermediate products between affiliates of vertically integrated multinationals became a major part of world trade flows (Casson, 1986; Grimwade 1989).[13] MNE total costs were reduced by shifting labour-intensive stages of production to countries with low unit labour costs. Two kinds of manufacturing production were pulled offshore. The first consisted of light, labour-intensive assembly operations, such as in the textiles and electronics industries. The second was basic industrial manufacturing of standardized mass-production products, such as stages in the automotive and steel manufacturing industries (UNCTC, 1988). These two moves in the 1970s introduced the so-called "new international division of labour" (NIDL) based on worldwide sourcing of cheap components and assembly (Mytelka, 1987).

In the fourth strategy, as firms increased global operations as a percentage of total operations, most American MNEs tightened their organizational structures to assert more control over their affiliates. Structures changed from simple international divisions and autonomous profit centres in the 1950s and 1960s to either functional divisions (where product diversity was low) or product divisions (where product diversity was high) in the 1970s (OECD, 1987, pp. 44-5). American MNEs now tend to adopt more globalized structures and exercise tighter control over their subsidiaries than European MNEs (OECD, 1987).

By the early 1980s the problems inherent in a strategy of plant rationalization and worldwide sourcing had become apparent. The distribution network was complex, flexibility of response to customer demands was low, and the link between innovation and production was stretched (Goldhar, 1989). These problems were aggravated by two technological developments (information technology and just-in-time manufacturing) and two major trade policy changes (the Canada-U.S. Free Trade Agreement and the prospect of a North American Free Trade Arrangement). I now turn to an analysis of these four changes, following which, I address the question of how the current technology and trade policy changes are likely to affect MNE organizational and locational structures in the 1990s.

TECHNOLOGY AND TRADE POLICY CHANGES IN THE 1980S

TECHNOLOGY CHANGES

The Information Technology Revolution

Van Tulder and Junne (1988, p. 6) define a core technology as one that leads to many products, has a strong impact on production processes, is applicable in many sectors of the economy, and eases obstacles to further investment. They identify two core technology clusters, which developed during the 1980s: information technology (IT), and biotechnology.

A recent study of MNEs by the United Nations Centre for Transnational Corporations (UNCTC) states that the "rapid spread of micro-electronics-based information technologies into production processes for goods and services has been one of the outstanding features of world development in the 1980s" (UNCTC, 1988, p. 42). Semiconductors, robots, computers, telecommunications hardware and software, and Computer Aided Design (CAD) equipment are the largest sectors in the IT cluster (Van Tulder and Junne, 1988, p. 8). Semiconductors are the basic component (the so-called "crude oil of the 1980s") of all microelectronic products; they raise product reliability and lower energy and materials requirements. IT is a generic or core technology in that it is highly flexible and can be introduced almost anywhere in the value chain. Within the manufacturing stage, four key ITs are: computer numerically controlled (CNC) tools, industrial robots, automated transfer systems and process-control systems (UNCTC, 1988, p. 42). These new ITs are linked in computer integrated manufacturing (CIM). CIM factories are "smarter, faster, close-coupled, integrated, optimized and flexible" (Goldhar, 1989, p. 261).

The key features of IT are integration and flexibility, both of which reduce average costs and generate system-wide gains in efficiency. IT lowers costs of labour, capital, energy and raw materials, reduces pollution, and increases the flexibility of production processes (Van Tulder and Junne, 1988, 19-27). IT is labour-saving, both as a product (substituting a single chip for number of moving parts) and as a means of production (e.g. word processors, robots). Labour productivity is increased through faster communications, shorter waiting and transport time, and higher quality control. IT saves on capital by making capital equipment reprogrammable, promoting the development and introduction of lights-out factories, reducing factory space, and cutting downtime. Raw material and energy needs are reduced by miniaturization and the use of telecommunications to adjust production to demand fluctuations. Pollution is reduced through waste reduction.

Flexibility of production processes is increased through the combination of microelectronics and reprogrammable machine equipment. Easton and Rothschild (1987) identify five areas in which flexibility can be improved through the use of IT: product, product mix, quality level, output volume and delivery time. Computer assisted design (CAD) equipment and computer numerically controlled (CNC) tools can reduce development and production time. Flexible automation together with computer-directed machining operations (CAD/CAM) allow firms to offer a broader range of products in small batches at low cost. Economies of scale at the plant level can be offset by increased economies of scope. It becomes easier to reconfigure products according to post-purchase customer requirements thus increasing product flexibility.

Just-In-Time (JIT) Manufacturing

The UNCTC (1988, pp. 42-7) claims that the second major force affecting MNEs in the 1980s is organizational innovation based on the concept of just-in-time (JIT) manufacturing. These new organizational innovations were developed in three areas: management of materials, human resources, and supplier relations. The main elements of JIT manufacturing are demand-driven production, minimization of downtime, pull-through work flow, inventory reduction, zero defect components, and total quality control. First adopted in Japan (where it is called the Toyota Production System), JIT manufacturing has spread in North America as American multinationals have been forced to adopt these techniques in order to compete with the more efficient Japanese multinationals, and as Japanese MNEs have adopted these process technologies in their new North American plants.[14] This is well documented in the new Womack et al (1990) study of the automotive industry.

Two key components of JIT manufacturing are reduced inventory and machine set-up time at each step in the production process. Both types of reduction can expose defects, which encourages the firm to introduce quality control systems designed to eliminate downtime which, in turn, reduces transaction costs in the form of manufacturing overheads within the firm. The multi-skilling and multi-tasking of workers necessary in JIT manufacturing encourage learning-by-doing and process innovations. JIT manufacturing is especially suited to complex, high-volume fabrication and assembly activities such as occur in the automobile, electronics and machinery industries (Lieberman, 1989, p. 221; Hoffman and Kaplinsky, 1988).

However, the JIT system also imposes certain requirements on supplier-MNE linkages. Proximity is very important, in order to maintain tight inventory schedules. MNEs must also collaborate with suppliers in order to schedule production. Components must be zero defective, which means that stringent quality controls also apply to suppliers. The expanding science base of manufacturing, because of its more specialized and complicated components, also requires closer coordination with suppliers. The result is that firms are signing longer run contracts with single contractors and many of those contractors are adopting JIT methods themselves.[15]

FMS: Linking IT and JIT Manufacturing

The JIT and IT revolutions together are creating a flexible manufacturing system (FMS). Hoffman and Kaplinsky (1988, p. 49) refer to the shift from traditional mass-production methods to a FMS as the shift from "machinofacture to systemofacture". This reflects the systemic integration necessary in FMS. Womack et al (1990, p. 13) call the new system "lean production" because a FMS uses less of everything: manufacturing space, inventories, labour hours, investment in tools, etc. Both teams of authors agree that the move toward flexible manufacturing systems will revolutionize manufacturing on a global basis.

The new factory of the future will be characterized by "decentralization, disaggregation, flexibility, rapid conversion of product lines, . . . surge and ramp-up and 'turnaroundability', responsiveness to innovation, production tied to demand, multiple functions, and close-coupled systems" (Goldhar, 1989, p. 262). This changes the definition of productivity from a cost base to a profitability base. It also shifts the focus of the core business from manufacturing to service. FMS reduces the economic advantages of large-scale factories, allowing a greater variety of low-volume, low-cost manufacturing to be concentrated in one location.[16] Goldhar notes, however, that since FMS is characterized by almost 100 percent fixed cost, the firm must increase its competitive segment scope and keep the factory working continually to reap the benefits from JIT manufacturing.[17]

The introduction of FMS affects the economies of location through its impact on economies of scale at the levels of the product, the plant and the firm (Hoffman and Kaplinsky, 1988, p. 346). During this century, there has been a tendency for all three types of scale economies to increase in the manufacturing sector. For example, in the automobile industry during the 1970s and '80s, product economies of scale provided an incentive for the world car, plant economies contributed to the emergence of the world factory, and firm economies generated

MNEs. Hoffman and Kaplinsky argue that new developments are still affecting scale economies through: the increasing importance of product innovation and quality relative to price; changing managerial perspectives in response to more discriminating consumers; and the use of FMS to reduce downtime and improve accuracy. On the other hand, the economies of massed resources, growth in indirect costs such as R&D, and the scale economies inherent in process industries all remain. In mass production industries, the net impact of these developments may well be to reduce plant and product scale economies; while scale economies rise in traditional small-batch sectors (Hoffman and Kaplinsky, 1988, p. 66, pp.347-53, p.362). For example, in core manufacturing industries such as automobiles, new engine and assembly plants are smaller size and designed to produce fewer units per year (1988, pp. 104-106). Thus, in Figure 3 both Hoffman and Kaplinsky and Womack et al (1990) predict that increasingly, the mature product stage will be characterized by flexible manufacturing systems. When coupled with the major trade policy changes outlined below, North American multinationals now face an environment far different from that of the 1970s.

TRADE POLICY CHANGES

BY THE END OF 1989 almost all major industries were operating in the context of global markets, competition, customers and suppliers (Hax, 1989). Ohmae (1985, 1989) argues that the Triad is the critical framework for MNEs engaged in global competition. To be a "true insider" in the world market, each multinational should occupy a position as a lead factory in each of the three leading blocs (North America, Europe, Asia). At the same time, each firm should develop "lead country models" (i.e. products tailored to the dominant markets) which can be minimally tailored for smaller markets. Globalization of markets is forcing multinationals to juggle simultaneously their goals of economic efficiency, national responsiveness and world-wide learning (Bartlett and Ghoshal, 1987a, b, 1989; Doz, 1986).

Globalization of markets was encouraged during the 1980s by state policies such as deregulation, the liberalization of trade and the integration of financial and capital markets through the G-7 and the European Monetary System (Investment Canada, 1990b). The perception that technology is the key to good trade performance and economic competitiveness has led governments to subsidize and protect their high-tech industries, and to encourage the production of highly-skilled labour (Van Tulder and Junne, 1989). These neo-protectionist policies are driving MNEs to make defensive intra-industry foreign direct investments in each Triadic bloc in order to protect their long-run market shares (Ostry, 1990).

The perception of trading blocs has mobilized governments in two ways. First, states are trying to slow down the breakup of the world trading system into blocs through the multilateral approach of the GATT Uruguay Round which is supposed to reduce tariffs, agricultural subsidies and textile restraints. It is also intended to contain non-tariff barriers (NTBs), and extend the umbrella of the GATT to include services, trade-related investment measures and intellectual property rights (UNCTAD, 1989, 1990). Second, states are simultaneously moving to position themselves within these blocs through regional treaties: the United States by signing a Free Trade Agreement (FTA) with Canada and by moving toward a North American Free Trade Agreement with Canada and Mexico; Europe by reducing its border controls and harmonizing national legislation(s); Japan by setting up subsidiaries in the Asian NIEs and within the other two blocs to protect its exports.

The Canada-US Free Trade Agreement

The 1989 Canada-U.S. Free Trade Agreement (FTA) is a preferential trading arrangement between Canada and the United States that is being phased in over a ten-year period. The FTA is broader than a simple preferential arrangement because it not only eliminates tariffs and sets up a framework for identifying and reducing NTBs between the two countries, but also liberalizes investment and professional labour flows between the two countries and promotes harmonization in certain areas.[18]

According to standard international trade theory, Canada, as the smaller country going into a free trade agreement, is expected to bear a larger share of the adjustment burden and reap a larger share of the trade gains. Adjustment pressures are created by static and dynamic effects. The static effects are of two types: trade creation and trade diversion (Hefferman and Sinclair, 1990, pp. 134-45). Trade creation occurs when high cost trade before the union is replaced by lower cost trade with a member country after the union. Trade diversion occurs when low cost trade before the union is replaced by higher cost trade with a member after the union. Dynamic effects include FDI flows in response to the trade creation and diversion effects, economies of scale and scope from the larger market, and terms of trade effects.

Several econometric studies have been undertaken that estimate the impact of the FTA on the Canadian economy.[19] The general conclusion drawn from these studies is that Canada would bear most of the adjustment pressures, facing relatively large employment losses in sectors including: textiles, paper products, petroleum products, glass products and electrical machinery. Sectors with relatively large projected employment gains are chemicals, iron and steel and nonferrous metals. On an overall basis, total employment should grow slightly and real income should increase. Both losses and gains are small for the United States, basically because the American market is expanded by only ten percent whereas the potential Canadian market is enlarged by ten times its original size.

The investment changes introduced in the FTA are also important for this analysis of MNE locational strategies. The Agreement puts an asymmetrical investment regime in place since the United States is bound to exempt Canada from any future inward FDI screening, while Canada retains the right to screen acquisitions of its financial intermediaries and largest corporations. Performance requirements are prohibited. Each country gives the industrial and service firms from the other country the right of establishment and national treatment, except in a few sensitive sectors. National treatment means that foreign firms must be treated no less favourably than domestic firms within a country's borders (i.e. the host country's rules apply).[20]

A North American Free Trade Arrangement?

Given the moves towards the development of a Triadic market consisting of three relatively autonomous trading blocs, it is perhaps not surprising that countries are positioning themselves to protect their export markets. Mexico, as one example, has served as a host country for U.S. multinationals since the 1800s. In the early 1900s the Mexican government restricted foreign ownership of many of its industrial sectors and has remained suspicious of American multinationals ever since (Weintraub, 1990). For many years the Mexican government followed an import substitution strategy designed to encourage domestic manufacturing and the growth of local capital. Foreign MNEs were forced to enter into joint ventures with Mexican partners and the percentage of foreign ownership was restricted. Non-tariff barriers (such as import licenses) were extremely high.

The one form of opening to the global economy occurred when the maquiladoras or in-bond plants were set up in 1965 (the same year Canada and the United States signed the Auto Pact). The maquiladoras constitute an export processing zone set up to attract FDI and encourage local assembly by taking advantage of low Mexican wage rates and reduced taxes (Dillman, 1983). With the American 806 and 807 tariff regulations levying duties only on the difference between the value of goods imported from Mexico net of American inputs, American MNEs were directly encouraged to set up offshore factories in Mexico and shift sub-assembly functions to these Mexican offshores. In the face of increasing competition from European and Japanese MNEs, American multinationals have made heavy use of maquiladora factories as a cost-driven method of responding to foreign competition (Dillman, 1983; Weintraub, 1987, 1990).[21]

During the 1970s, Mexico was an oil exporter and a heavy borrower. With the drop in world oil prices in 1981, Mexico suddenly found itself with a severe debt crisis by 1982. As a result, President de la Madrid began opening the general Mexican economy to international trade and foreign investment in the mid-1980s. Foreign investment rules were relaxed and Mexico joined the GATT in 1986. By 1987, 64 percent of all Mexican exports and 80 percent of manufactured exports were going to the United States (Weintraub, 1990, p. 106).

The signing of the FTA, however, meant that Mexican exporters (other than maquiladora exports) would be at a disadvantage, relative to Canada, once the FTA was completely phased in, in accessing their major market, the United States. Canada went into the FTA to protect its access to its largest market; however, Canada's entry diverted trade from Mexico. This trade diversion effect is particularly noticeable in those sectors where both Mexico and Canada export similar products to the United States and Mexico had been the more efficient supplier. Weintraub (1990, p. 111) suggests that trade diversion is likely in the following product lines: automobiles, petrochemicals, iron and steel and other metals, paper products, textiles and apparel, and machinery. Since exports of Mexican manufactured goods to the United States have been growing faster than other exports, Weintraub argues that this list probably understates the trade diversion in the manufacturing sector.

The triangular trade between the three North American countries is noticeably unbalanced. In 1987, the United States sold 18 percent of its total exports to Canada and six percent to Mexico; it imported 18 percent of its total imports from Canada and five percent from Mexico. Canada sold 76 percent of its exports to the United States but negligible amounts to Mexico, and imported 66 percent of its imports from the United States with similar negligible imports from Mexico. The U.S.-Canada trade link is therefore much larger and stronger than either of the two other sides of the triangle (Hart, 1990).

In 1988, 68 percent of Mexico's total exports were to the United States. Considering this, the trade diversionary impact of the FTA on Mexico is clear. This effect might be offset if Canada and the United States buy more Mexican products because of high income gains produced by the FTA. However, the effect on income in the United States is expected to be small (since the United States is the larger partner) and Canada buys very little from Mexico. In addition, Canadian exporters are to some extent now sheltered under the FTA from future U.S. protectionist legislation. If Canada, but not Mexico, were to be exempted from the American NTBs (such as countervailing duties), an additional trade diversion effect would occur.

As a result of both the realities of a Triadic global economy and the trade diversion effects of the FTA, when Salinas succeeded de la Madrid as president of Mexico in December 1988, he approached the U.S. government about negotiating a U.S.-Mexico free trade agreement. The U.S. government and Mexico have now agreed to start joint talks on such an agreement.

Canadians are now debating whether to join the talks as an observer or as a full participant in the spring of 1991 (see Molot, 1990). Two separate trade agreements — one with Canada, the other with Mexico — would put the United States into a hub-and-spoke arrangement (with the U.S. as the hub and Canada and Mexico as spokes) which would give relatively more benefit to the United States (Lipsey, 1989).[22] A separate U.S.-Mexico agreement would also adversely affect Canadian trade preferences negotiated under the FTA. However, a full triangular arrangement with all three countries as equal partners will clearly be difficult to negotiate given the substantially lower level of economic development and wages, the much more rural and agricultural nature of the Mexican economy, and the traditional Mexican suspicion of American multinationals (Hart, 1990).

ORGANIZATIONAL AND LOCATIONAL RESPONSES OF MULTINATIONALS

MNE Locational Responses

Responses to Technology Changes Many economists and scientists are now suggesting that the global economy is going through a third technological revolution, based on the new core technologies — information technology (IT) and biotechnology (Van Tulder and Junne, 1988).[23] Information technology is revolutionizing the world economy through a closer linking between buyers and sellers. IT is also changing the concept of a "market" — from a geographic location to a network of computers linked by telephone lines. As the railroad revolutionized transportation of goods within and between national markets by lowering transportation costs to its downstream industries, IT is revolutionizing access to services by making them available virtually anywhere in the world by telephone or computer hook-up. Just as lower transport costs overcame tariff barriers, brought markets closer together and increased trade generally, so also are lower communications costs overcoming non-tariff barriers, thereby making previously untraded goods and services tradeable.[24]

The technological revolution is transforming society; new technologies are replacing traditional methods and precipitating large structural changes in industries. In the industrialized countries production is splitting into three distinct types based on the combination of IT and just-in-time manufacturing: 1) materials-based, standardized, mass production, and low value-added operations where cost minimization is important; 2) flexible, specialized batch production operations that are customized and high value-added; and 3) the new information-based, high value-added industries such as engineering consulting, data processing, advertising and financial services.

Computer-integrated manufacturing (CIM) and flexible manufacturing systems (FMS) are "levelling the playing field" by virtually eliminating unskilled labour costs as a source of competitive advantage. However, the need for highly skilled workers such as systems and industrial engineers, product designers, scientists and technicians will increase. Given the global mobility of capital, the competitive edge shifts to areas suitable to knowledge-based production, i.e. cities in the industrialized countries close to universities and research institutes. The NIEs may therefore have difficulty retaining their current share of MNE manufacturing activity unless they increase their country-specific advantages as a location for knowledge-based manufacturing (Junne, 1987).

The worldwide sourcing strategy of using offshores to reduce MNE costs which was practiced widely during the '70s and '80s, may decline in the 1990s.

Markides and Berg (1988) argue that offshore manufacturing has harmful long-run effects on American multinationals. The practice may produce short-run cost savings, but it causes other problems for the firm. Although labour costs are reduced, other costs (inventories, transportation) go up. Low wages often mean low productivity, so unit labour costs may actually be close to home country levels. Also, rising wage rates in offshore locations may force exits and a continual search for lower cost sites — an activity that, in itself, is not without cost. The MNE may create a "hollow corporation" as it shifts key production processes outside the firm. This can happen if the product development and manufacturing components are separated with a resulting reduction of innovation rates. Collaborators and subcontractors may become competitors once the sharing of trade secrets, learning-by-doing and reverse engineering increase host country expertise. In addition (as the obsolescing bargain predicts) states may raise their expectations of plant contributions to the local economy, and so demand more nationally responsive foreign subsidiaries.

In view of the importance of the IT-JIT revolution to the global effectiveness of MNEs in the 1990s it is appropriate to ask to what extent American multinationals have already made this adjustment. According to Wheelwright (1987), the IT-JIT revolution is making its way into the American manufacturing environment only slowly. Wheelwright (1987, pp. 96-8) notes that a 1984 McKinsey and Company study found that most adopters of CAD/CAM were using it either as a productivity tool for existing workers (for cost reduction) or within a single department (cost reduction plus enhanced product features); few firms were using it in a systematic manner across multiple functions and levels (to realize the full CAD/CAM potential). Wheelwright contends that American manufacturing firms are stuck with a static optimization view of technology that emphasizes the vertical division of tasks in the value chain. Increased specialization of function, finer divisions of labour, and economies of scale through mass production are treated as key cost-reduction strategies. He argues that a dynamic evolution view of manufacturing is required to restore the competitiveness of American firms. This calls for ongoing training of lifetime employees, product development as a team effort, in-house technology capabilities, and horizontal integration across tasks.

Both the Canadian and American governments are now keeping statistics on the introduction of IT into manufacturing — the so-called advanced manufacturing technologies (see Statistics Canada, 1989; U.S. Department of Commerce, 1989). McFetridge (1990) analyzed recent data to determine the factors that affect relative adoption rates. He found that establishment scale, and the percentage of establishments in an industry already using IT are significant determinants of IT adoption rates. Proxies for domestic and international multiplant economies of scale were not significant, nor was establishment age. He concludes that most of these technologies are now available on an "off the shelf" basis to Canadian firms, and are being adopted in Canada as quickly as in the United States.

What does the IT-JIT revolution mean for possible locational decisions of U.S. multinationals in the 1990s? If knowledge is displacing labour and capital as the underlying factor determining the global allocation of production, new strategies are needed to cope with this change. As the knowledge-intensity requirements for production increase, firm-level scale economies should increase. Catalogue shopping and franchising, the two major ways that American multinationals accessed lower cost labour and materials in the 1980s, will increasingly be replaced by strategies based on the Triad and lead products, where innovators and producers work closely together in lead factories (Flarety, p. 1088). The need to access market information and achieve an insider status within at least two of the three Triad blocs is likely to mean (particularly in the light of the difficulty American multinationals are having trying to set up within Japan) that American multinationals will establish their lead factories in Europe, rather than in Canada. A key function of these lead subsidiaries will be to access new technology. Considering the short product life cycles that the IT revolution has partly generated, it may become increasingly important for MNEs to have access to the latest technology. Often that technology will not be inhouse. Just as in the 1970s the MNEs set up offshore factories to source cheap labour worldwide, in the 1990s MNEs may set up outpost factories to access cheaper and newer knowledge (Chesnais, 1988). Instead of the parent firm exporting technology to its subsidiaries, the subsidiaries may be expected to play a new role — to access and export the newest technology to the parent and other technologically advanced affiliates of the MNE. Outpost factories, both as 'windows on foreign science' and as strategic partnering initiatives (where two or more MNEs pool highly skilled and financial resources to perform basic research, then develop their own independent product lines based on that research) may become even more common in the 1990s. Outposts, however, may be located near demand-driven factories such as contributors or lead plants in order to link research more closely with production. In a knowledge-intensive production system, worldwide access to knowledge is expected to replace the search for cheap labour sites as the driving force behind FDI in the 1990s.

One important issue is whether R&D will be decentralized. Kay (1988) argues that R&D activity is characterized by non-specificities, lags, uncertainty and high cost, with the first three falling and the fourth rising as a new project moves downstream towards "final launch". Centralization of R&D activity is encouraged by all four factors. However, there are good reasons to devolve some R&D to subsidiaries: the allocation of R&D costs across divisions is difficult, and the need to understand users requires close contact between researchers, producers and sellers. Kay argues that organic structures with lateral relations, which encourage networking, are more likely to encourage innovation than traditional hierarchical control models. Such lateral relationships are normally part of flexible manufacturing systems (Masahiko, 1990).

In the 1980s flexible manufacturing systems were used by Japanese auto firms to capture economies of scope that could offset the economies of plant scale available to auto MNEs engaged in traditional mass production. Now, American auto MNEs are increasingly adopting FMS techniques, with varying results (see Womack et al, 1990, Chs. 9 and 10). The IT-JIT revolution is expected to spread throughout the industrial and service sectors during the 1990s. FMS factories are smaller, utilize floor space more effectively, and have fewer inventories on hand. Economies of scope are also easier to achieve since downtime required to switch product lines is substantially reduced. In effect, the long-run average cost curve may flatten, so that firms of different sizes can operate with comparable efficiency.

In Canada, the introduction of flexible manufacturing systems is likely to have mixed effects. Canadian affiliates of American multinationals traditionally have performed both resource-based and demand-driven strategic functions (see Figure 2). So far, the IT-JIT revolution has had its strongest influence on manufacturing firms, although it is also reducing resource-intensity at all production stages. IT-JIT may mean that our small market can eventually be served as efficiently by a small flexible manufacturing system as by a large rationalized factory.[25]

However, economies of scale at the level of the firm are likely to become more important as FMS spreads throughout the manufacturing sector. As primary activities become a smaller and smaller part of total costs, the need to spread support activities (see Figure 1) over larger markets increases. Thus, the demand-driven plants such as servers can more easily upgrade to higher technological levels. In industries with a stock of well-trained scientists and technicians, Canadian subsidiaries may well be able to convince their American parents that they have the capability to become focussed factories and/or achieve world product mandate status, perhaps in certain regional or global product niches. However, because of the relative homogeneity of the American and Canadian markets, it is unlikely that Canadian affiliates will be given the opportunity to become lead factories.

In addition, the IT-JIT revolution requires close proximity and contact between MNEs and their suppliers; this is essential in order to run a smooth flexible manufacturing and/or assembly system. Thus, many manufacturing firms are adopting sole-source supplier linkages (in effect, creating "satellite" plants), requiring suppliers to be located close to the final assembly stage plants. Offshore plants in the NIEs may well become more footloose and relocate back to the OECD countries (see Figure 3). Canada may be able to capture some of this production, depending on its domestic adoption rates of the new technologies. (Mexico in particular is likely to benefit from this trend, especially if a North American Free Trade Agreement [NAFTA] is negotiated.) However, as Milne (1990) notes, not all industries will have this distance-reducing effect — depending on the relative sizes of the subcontractors and buyer firms, and the ability and willingness of all firms in the vertical chain to adopt JIT methods. If the manufacturing buyer is smaller than the supplier and cannot absorb all of the subcontractor's output, then the supplier must be responsive to the demands of two or more manufacturers.[26] Where distances are not too large, MNEs may well locate new but separate in-house upstream plants (to manufacture components) close to assembly plants. This means that rapid adoption and diffusion of IT-JIT methods may be essential for Canadian firms in the 1990s if they expect to retain their share of American operations and upgrade their technological functions.

Responses to Trade Policy Changes

The signing of the FTA marks a new relationship between American multinationals and their Canadian affiliates. With the eventual elimination of tariffs in both countries, one of the key factors of Canadian economic life since 1897 will disappear (or will be at least reduced, depending on NTBs). Most of the miniature replica plants of the 1960s and 1970s are already gone largely because of the influence of tariff reductions under the Tokyo Round (Bishop and Crookell, 1985). To the extent that inefficient plants still remain, these subsidiaries must find new functions in the 1990s. They must upgrade, rationalize or exit. MNEs are likely to be better placed than domestic firms to make these adjustments due to their larger size, the oligopolistic market structures in which they operate, and the volume of intra-firm linkages they can use to cushion change (Bishop and Crookell, 1985; Grimwade, 1989, pp. 384-91; Richardson, 1990).

Rugman (1990, pp. 118-46) argues that there are three categories of American branch plants: (1) tariff factories that cannot survive after the FTA; (2) branches that can survive after the FTA due either to their parent's FSAs or to high Canadian exit barriers; and (3) branches set up for reasons other than tariffs and NTBs and which keep their competitive advantages after the FTA. He contends that most of the larger Canadian subsidiaries are in category 3 and are already internationally competitive. The other affiliates may need either to exit or be integrated into a global network. He therefore expects globally rationalized plants to substitute for miniature replicas, particularly in the long run, although some miniature replicas will persist in industries where scale economies are small and entry barriers high.

Given the IT-JIT changes discussed earlier, I contend that it may be easier in the 1990s for the remaining miniature replica plants to choose a strategic direction that increases their technological contribution and divisional autonomy within the MNE. These factories can either move downward (see Figure 2) to become focussed factories or upward to become world product mandates. They may even move backward to become source factories by taking on subassembly functions if the MNEs bring offshores back from the Asian NIEs. Bishop and Crookell (1985) expect that the choice will lie between global rationalization along product lines or world product mandating (strategies 7 or 9 in Figure 2). They conclude that both strategies integrate the subsidiary more closely into the MNE's overall organizational and location structures. They argue that without Canadian inducements by both the state and the subsidiary, the MNE is more likely to respond by rationalization than world product mandates.

However, economic integration via trade policy changes is unlikely to encourage Canadian affiliates to become lead factories or major innovation centres. Cantwell (1988, this volume) argues that preferential trading blocs encourage a regionally integrated strategy by multinationals that, in turn, encourages a virtuous-vicious circle outcome. Centres of technological innovation tend to become more so, promoting a virtuous circle; however, stagnant sectors tend to atrophy more quickly, generating a vicious circle. To the extent that this occurs under the FTA, areas such as Southern Ontario, California and parts of Texas should benefit most in innovative activity, while peripheral areas should grow more slowly.

The impact of the FTA on Canadian subsidiaries cannot be considered alone however. I have argued in this paper that the essence of multinationality is foreign production and that FDI and intra-firm trade are joint manifestations of the MNE's globalized demand-cost-supply perspective. Most analyses of free trade focus specifically on trade without incorporating the key factor that most of it is intra-firm and related to FDI and foreign production decisions.[27]

American multinationals are already integrating Mexico into their value chains (see the Automotive Parts Manufacturers' Association, 1990) and can be expected to increase this integration if a NAFTA is negotiated. These Mexican affiliates may be complementary factories to Canadian ones (i.e. if they produce at different stages in the value chain) or they may be competitive (i.e. if they produce at the same stage). The impact of a NAFTA on the Canadian affiliates is likely to be very different, depending on this relationship.

When Mexico and Canada can perform similar stages of production within the MNE, they act as competitors. Thus, the FTA now protects the Canadian affiliate at the expense of the Mexican affiliate since U.S. tariffs have been lowered for Canadian exports but not for Mexican exports. Conversely, should a NAFTA be introduced, the Canadian affiliate would suffer unless it could become more competitive through restructuring. Note that the difference between the FTA and NAFTA here assumes that transfer price manipulation is not used to offset the U.S. tariff; Sections 806 and 807 do not apply (otherwise the tariff would be minimal); and that government taxes and subsidies do not offset the tariffs.[28]

In the case where Canada and Mexico perform different stages in the value chain, the comparison of a NAFTA with the FTA leads to quite different results. Here, the two affiliates should be complementary, and a tariff at one stage hurts all stages of the MNE. Thus, the introduction of the FTA benefits both the Canadian and Mexican affiliates through increased American demand for their intra-firm products; a NAFTA would have a similar effect.

It is therefore crucial to know the respective roles of the two subsidiaries before predicting that Canadian jobs will be lost to Mexican workers after the introduction of a NAFTA. There has been little research to date on this question. This is not just a simple matter of examining the current locational roles of Canadian and Mexican affiliates within American multinationals. The reduction of tariff and non-tariff barriers should force MNEs to re-evaluate their locational strategies. As we saw in Figure 2, depending on the primary motivation for the FDI (resource, cost or market), free trade could cause either an upscaling or downscaling of foreign factories. Some argue that the natural response will be a cascade effect, shifting low-wage activities to Mexico, and knowledge-intensive activities to the United States and Europe (Fleck and D'Cruz, 1987). Canadian subsidiaries may therefore be left with either globally rationalized plants or a more innovative but narrower role based on world product mandates. Alternatively, Canadian affiliates may be reduced to servers and importers. A move backward in the value chain whereby Canadian affiliates act as source factories is unlikely if a NAFTA were negotiated, since cost-driven source factories are more likely to be located in Mexico than in Canada.

Also key in this regard is the impact of the IT-JIT changes on firm cost structures. Flexible manufacturing systems may reduce economies of scale at the plant and product level for mass production industries. It may therefore be possible for Canadian branch plants to offset the attraction of low unit labour costs in Mexico (and other NIEs) if automation proceeds rapidly enough. The net result could be fewer but more highly skilled jobs in manufacturing, resource industries and business services, and would likely depend on the core competencies of the Canadian affiliates and their ability to identify and use these FSAs in a Canadian context (see also Crookell, 1990a, pp. 22-30; Johnston, 1990).[29]

MNE ORGANIZATIONAL RESPONSES

As discussed earlier, several organizational structures are available to MNEs, ranging from the simple international division to complicated matrix structures. *Business International* (1988, pp.6-7) argues that three of the current structures contain flaws which may make these structures obsolete in the 1990s. The global product structure is expensive and does not encourage sharing resources across divisions or transferring resources or products internationally. The matrix structure is too complicated. The international division structure is designed for MNEs with a small international business, not for today's global players. *Business International* concludes that the mixed and matrix overlay structures, due to their synergistic properties, are likely to predominate among MNEs in the 1990s. We can explain this argument by examining the impact that technology and trade policy changes are likely to have on MNE organizational structures.

In the 1970s MNEs had to choose between a centralized and decentralized organizational structure. Centralized structures allowed for high control but had high (organizational) cost structures; decentralized structures were low control but had low organizational cost. Most MNEs adopted "command-and-control" systems that emphasized decentralized subsidiaries, central service staffs, personnel management, and the separation of policy making from operations (Drucker, 1988).

The IT revolution, however, means that telecommunications networks can be used world-wide to link MNE affiliates and provide centralized corporate data bases for use by both headquarters and affiliates. This improves centralized control by the parent firm and creates new information channels within the organization. Information technology allows the parent firm to monitor and control large operations more effectively with fewer middle managers to analyze and relay information. IT can therefore create an information-based organizational structure that is downsized and flattened compared to 1970s corporations, by providing diagnostic tools for capital budgeting decisions, reducing the need for service staff, and substituting horizontal task forces for the vertical sequencing of value activities. IT has already been used in the 1980s to downsize and restructure the MNE. American organizations have shed more than one million managers and staff professionals since 1979 (Applegate et al, 1988, p. 128), substituting expert and executive information systems.[30]

The JIT manufacturing revolution is also affecting the organizational structure of multinationals in other ways. First, the adoption of JIT process technologies requires the introduction of new labour management techniques with less hierarchical control (Womack et al, 1990). Thus, more control over production is ceded to the plant floor in order to ensure overall quality control.

Second, previously loose relationships with supplier firms are changing as JIT induces MNEs to adopt tighter supplier-buyer linkages, in effect extending the value chain by bringing suppliers into the chain as satellites. Individual suppliers are given more responsibility for research and product development, but are also drawn more closely into the control structure of their downstream MNE buyer.

Third, the wholly owned subsidiary has been the dominant mode of entry into foreign markets for decades. Recently, however, MNEs have been engaged in minority equity ventures, subcontracting arrangements, and strategic partnerships. The variety of legal contractual arrangements is significantly higher now than it was 10 years ago (Eden, 1989c). MNEs are turning to partnerships, joint ventures and other co-operative arrangements as a way of spreading the high overhead costs of technological innovation, linking with firms of complementary skills and resources, and achieving "insider" status (UNCTC, 1988). Firm-level economies can be captured either through the value chain, continuing to make global MNEs the dominant organizational firm structure in the 1990s, or through technology-sharing joint ventures, spreading high R&D costs over several firms (Hoffman and Kaplinsky, 1988). Whether strategic alliances will come to dominate global industries in the 1990s is not yet clear. Mytelka (1987) believes that such alliances are the "wave of the future" arguing that new MNE strategies will involve decentralizing R&D operations from the home country to OECD host countries, engaging in strategic partnerships to share R&D costs, and sharing knowledge production with universities and research institutes.

From this I conclude that Canadian affiliates are likely to be more closely integrated into their parent's organizational structures in the 1990s, and that subcontracting firms are likely to face similar pressures. Such organizational integration is already being encouraged by both technological and trade policy changes that are creating new information channels within the MNE. These integrative pressures should be strongest for globally rationalized subsidiaries where nationally responsive strategies have a low priority. Even if Canadian affiliates are successful in obtaining world product mandates, as Bishop and Crookell (1985) have shown, such WPMs also involve tighter links with the parent firm. Thus, I believe that Canadian affiliates are likely to be drawn more closely into the global locational and organizational structures of their American multinational parents in the 1990s.

CONCLUSIONS

THE PURPOSE OF THIS PAPER was to show how changing technological and trade policies affect multinational organizational and locational strategies, and in particular how Canadian affiliates of American multinationals are likely to be affected by these changes. I contend that both MNE organizational and locational changes can be expected as a result of information technology and just-in-time manufacturing and as a result of the introduction of the Canada-U.S. Free Trade Agreement and a possible North American Free Trade Agreement. Technological changes have altered the playing field on which MNEs compete; simultaneously, trade policy changes have altered the rules of the game.

I have argued here that both technological and trade policy changes are likely to increase the economic integration between American multinationals and their Canadian affiliates. Technology changes reduce transportation and communications costs, allowing closer monitoring of distant affiliates, and encouraging global strategic planning and production. Trade policy changes encourage MNEs to gear up for global competition by rationalizing production within the North American bloc. MNEs are likely to replace their old locational strategies (searching for natural resource sites in the 1950s and for low-cost labour sites in the 1970s and 1980s) with a new strategy in the 1990s of worldwide sourcing of new product and process technologies. The competitive edge should go to MNEs that source technology, rather than labour or resources, on a worldwide basis.

Canada is in a mixed position with respect to these changes. With the exception of automobiles, its major exports are still resource-based. Its domestic firms are not major producers of technology; rather, they are "fast followers" (Niosi, 1985) that rely on marketing advantages (Rugman, 1990). Many Canadian foreign-owned subsidiaries are either resource-based, designed to service the local (and small) market, or already integrated into North American production and assembly (e.g. the Auto Pact). These affiliates face opportunities for new strategic roles within their MNEs; however, these roles may contribute less to the Canadian economy in terms of skilled jobs and technology transfer. Much depends on the abilities of individual affiliates to identify and exploit their core competencies, based on their Canadian locational advantages, within their parent's organizational and locational structures. The identification of and investment in these FSAs are crucial steps in maintaining Canada's share of high-tech factories with lead products. Canadian affiliates will have more freedom to define their strategic roles within MNEs in the 1990s; however, they will have to plan their moves strategically, based on rational assessments of their core competencies and how they can be exploited in a world of global competition.

ENDNOTES

1. Eden (1990) looks at the implications of other political and market forces that affect Canadian firms, including the international diffusion of economic power, globalization, 1992, the Uruguay Round and the rise of U.S. protectionism. For a review of the 1980-89 period see Eden (1989a).
2. I am indebted to Maureen Molot for this analogy.
3. Most authors have focussed on American multinationals and their responses to either technological change and/or globalization. See Porter (1986), Doz (1986), Ohmae (1985, 1989, 1990) and Barlett and Ghoshal (1987a,b, 1989). On the strategic management of MNEs in Canada in response to globalization and the FTA see Rugman (1988, 1990), Rugman and D'Cruz (1990) and Investment Canada (1990). For an earlier view see Bishop and Crookell (1985).
4. In 1983 Canada was a home country for 4.9 percent and a host country for 11.1 percent of the world FDI stock. Between 1975 and 1983 the outward stock of FDI grew at an average annual rate of 13.6 percent, while the inward Canadian stock grew at an average annual rate of 6.3 percent. Clearly, the traditional picture of Canada as a host country is changing as the net stock position appears to be reversing. Statistics are from Dunning and Pearce (1988).
5. See Eden (1989b) for an application of this model to the international pharmaceutical industry.
6. For a more detailed discussion of core competencies see Prahalad and Hamel (1990) who argue that core competencies (1) provide potential access to a wide variety of markets, (2) contribute significantly to customer satisfaction, and (3) are difficult to imitate. They argue that core competencies can be lost if firms do not understand and invest sufficiently and effectively in their areas of competency. This is an interesting and important argument since most work on the firm-specific advantages of MNEs assumes that firms know what their competencies are, how to exploit them and that the FSAs are fixed. See also Cantwell (1987), who takes a dynamic approach, allowing for investment in FSAs.

7. One factor that is important in our analysis is the growing tendency to source technology worldwide; i.e. rather than the MNE using FDI to earn rents on its own technology, multinationals are now moving abroad to access technology and share R&D costs with strategic partners — such as universities, governments and rival firms.
8. This list has been developed from the following taxonomies. Ferdows (1989) identified six generic strategic roles for foreign factories: offshore, source, server, contributor, outpost, and lead. D'Cruz (1986) provided a list of six strategic types which he calls "the subsidiary mission grid": importer, satellite, globally rationalized, local service, branch plant, and world product mandate. D'Cruz argues that the first three have little decision-making autonomy and are progressively more globalized; the second three have high autonomy and are also progressively more globalized. Bishop and Crookell (1985) compare three strategies: miniature replicas, rationalized factories and world product mandates, and argue that the FTA is eliminating the miniature replica as a viable long run strategy in Canada. See also Crookell (1990, pp. 15-22). The Premier's Council report, *Competing in the Global Economy, Vol. 1* (1988), distinguishes between resource-based, low-wage and high-wage businesses where the third category includes mature, high-growth and emerging businesses. My taxonomy builds on and extends this list to encompass the three types of factories: resource-based, cost-driven and market-seeking, and to distinguish among these by their level of technological sophistication.
9. Rising wage rates in the NIEs are now forcing countries such as South Korea and Taiwan to upgrade the technical and educational skills of their labour force in order to encourage existing foreign investors from turning their plants from offshores into source factories.
10. See Etemad and Dulude (1986) and Pearce (1988) for further analyses of world product mandating in Canada. The definition of a WPM used here is broad and includes all production, design and marketing functions.
11. Ferdows (1989) found no stand-alone R&D outposts; information collection was usually assigned to a lead factory. However, I argue that strategic partnering between high-tech firms in Europe under the ESPRIT program can be considered as outposts. Recent FDI by European and Japanese firms into Silicon Valley also appears to be partly driven by outpost considerations. (See the Teece paper in this volume.)
12. Not all firms pass through all stages. Ninety percent of American MNEs passed through the international division phase while most European MNEs skipped it entirely (OECD, 1987, p. 46). Japanese *sogo shosha* or trading companies have assumed the export department role for many Japanese MNEs.
13. This type of intra-industry trade should more properly be considered as inter-industry trade since it takes place at different stages of production. Trade statistics normally include semifinished and finished goods in the same category. However, the offshore processing and final assembly package

typical of, for example, the auto industry, is not the same type of intra-industry, two-way trade in finished goods, and does not have the same effects.

14. The key components of JIT manufacturing are (1) Demand-Driven Production: the philosophy of shifts from producing to stock to producing to order so that production is in smaller batches with greater variety. (2) Minimization of Downtime: quick changeovers and setups are essential and production workers must be trained to work on a variety of machines. (3) Pull-Through Work Flow: factory layouts must be changed to encourage smooth flow-through of batch production. (4) Inventory Reduction: firms must switch from "just-in-case" storage of inventories to "just-in-time" inventory control. (5) Zero Defect Components: components must be perfect quality in order to maintain pull-through work flow. (6) Total Quality Control (TQC): preventive maintenance and quality control responsibility shift to production workers. TQC includes prevention costs (including quality circles), appraisal or monitoring costs, costs of internal failure (costs of fixing bad quality before it leaves the factory), and costs of external failure (warranty claims, customer illwill, etc). See Shank (1990) for a discussion of the impact of JIT on cost management techniques. (7) Knowledge-Intensive Production: workers are multi-skilled and are paid according to skill level and output quality. See UNCTC (1988, pp. 42-7).
15. Milne (1990) notes that all links in the contracting chain must adopt JIT methods if the strategy is to produce inventory and cost savings. If the secondary manufacturers adopt JIT but the subcontractors do not, then inventory holdings are merely shifted upstream to the subcontractors. These inventory costs will be passed on to manufactures.
16. See also Drucker (1990) on the postmodern factory.
17. Detailed studies of the introduction of flexible manufacturing systems can be found in Schonberger (1986, 1987). See also Wolf and Taylor in this volume on employee and supplier learning in the Canadian automotive industry.
18. Good studies of the FTA include Lipsey and York (1988), McRae and Steger (1988), Dearden, Hart and Steger (1989) and Morici (1990, forthcoming).
19. The best known of these studies are Harris and Cox (1983), Brown and Stern (1988) and the Economic Council of Canada (1988). See Morici (1990, forthcoming) for reviews.
20. Rugman and Verbeke (1990) have argued that the national treatment principle embedded in the FTA is a significant gain for Canada. This principle allows the host country's tax and FDI rules to be the standard for both domestic and foreign firms operating within domestic borders. Thus American rules apply to firms working in the United States and Canadian rules to firms working in Canada. Europe under 1992, on the other hand, is moving to mutual recognition of each other EC member's rules so that home country rules apply. This forced harmonization — either indirectly through mutual recognition or directly through the many harmonization

directives with respect to standards currently being made by the EC Commission — means that the relative strength of home countries within the European Community will lead to the strongest home country's rules predominating in the long run (e.g. German banking rules). No such forced harmonization of investment rules occurs under the FTA (although there is provision for future harmonization of some standards and social areas). Rugman and Verbeke therefore conclude that Canada is better protected under national treatment than under the mutual recognition approach.

21. Weintraub (1990, p. 107) notes that the figures are actually higher since maquiladora exports are not recorded in trade figures, but in "transformation services" (transforming goods into a more processed form).
22. However, I argue that in the automotive industry there already exists a hub-and-spoke model. The Canada-U.S. spoke is regulated by the 1965 Auto Pact and the 1989 FTA; the Mexico-U.S. spoke is regulated by the 1977, 1983 and 1989 Mexican directives to the auto industry, and the combined effects of the maquiladoras and 806/807 U.S. tariff rebate programs. In each case, the host country (Mexico or Canada) appears to have negotiated the spoke clauses without explicitly taking the other spoke agreements into account. To what extent this has benefited the hub — the United States (government, country or MNEs) — or the spokes has not been investigated. The various regulations are briefly outlined in Automotive Parts Manufacturers' Association (1990).
23. The first technological revolution occurred two hundred years ago with the advent of the steam engine and capital goods production in factories (Mytelka, 1987). What is now called the "old international division of labour" was created whereby European manufacturing countries bought raw materials and primary products from their colonies and other less developed economies. The second technological revolution began in the late 1880s with the appearance of cheap electrical power, synthetics and plastics.
24. Technology affects not only the globalization of trade in services, but also the overall volume of trade, since many goods have a high service content. GATT (1989, 3) concludes that "the greater the availability and the lower the costs of the needed services, the faster the pace of globalization of markets" and that access to competitively priced producer services is a key determinant of a firm's ability to compete. Rugman and D'Cruz (1990) have argued that services need to be increasingly competitive for manufacturing to compete in the Triad.
25. Thus, the plant economies of scale argument that drove economic predictions of the benefits from the FTA (see Harris and Cox, 1983) may become less important in the future.
26. Milne (1990) notes that in the United Kingdom the relatively small size of the electronics plants in the consumer electronics industry does not justify subcontractors moving closer to these buyers. In autos, however, large plants can gain control over suppliers because of their different relative sizes.

27. See, however, Yannopoulos (1987) on the investment impacts of trade diversion and trade creation on European MNEs in response to tariff preference schemes. He argues that the size and direction of FDI flows depend upon (1) the trade diversion and creation effects, (2) previous patterns of servicing donor markets, and (3) the relative FSAs of donor and beneficiary firms. My analysis follows the same pattern but for a free trade area (the FTA), rather than unilateral tariff reductions.
28. When tariffs are levied on an *ad valorem* basis, MNEs can underinvoice intra-firm trade flows to reduce the tariff. The impacts of changing Canadian and U.S. tariffs, corporate income tax and transfer pricing policies on horizontally integrated MNEs are analyzed in Eden (1990b). See also Eden, 1988a.
29. For industry-specific responses to trade and technological changes, a useful reference is the Ontario Premier's Council report and background studies (1988) which use the Porter value chain approach to examine selected Ontario industries in the resource, low-wage, and high-wage sectors. The studies argue that knowledge is replacing resources and labour as the key factor of production and that Ontario must introduce new policies to help firms introduce FMS.
30. For example, Applegate et al (1988, p. 132) argue that the IT revolution will affect MNEs in the 1990s in the following ways: both small and large scale MNEs will benefit simultaneously, and will adopt more flexible and dynamic organizational structures; the distinctions between centralized and decentralized control will blur; and the MNE focus will shift to projects and processes from tasks and standard procedures.

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DISCUSSANT'S COMMENTS

DISCUSSANT:
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IN HER PAPER, Lorraine Eden argues that the revolution in information technology may enhance the capacity for centralized control within multinational enterprises but that, simultaneously, it also encourages the dispersal of production sites. Just-in-time arrangements suggest that those production sites may become clusters of activity as suppliers situate themselves nearby. She then focusses on the key question, where will these clusters of production be located? She demonstrates how a North American Free Trade Area, which includes Mexico, could alter multinational corporate decision-making, compared to the U.S.-Canada Free Trade Area, which excludes Mexico.

My own research adds a further complicating factor, which may strongly affect the location of multinational production in "footloose" industries such as automotives, computers, and petrochemicals.[1] In the course of conducting my research, I found that performance requirements (local content, export, or trade balancing requirements) play a substantial role in fixing the location of world-scale facilities in these sectors, and that Mexico is a sophisticated user of such measures.

One might think that the prohibition of TRIMs in the Uruguay Round would be an appropriate means to create a level playing field for the location of production. However, the research showed that developed countries utilize fiscal incentives with much the same effect as performance requirements. (For example, cash grants of 60 percent of the cost of a project for facilities far larger than needed, were used to supply a local market like Ireland.) Such fiscal incentives occur at the sub-federal as well as the federal level. (American states have granted $100-$300 million or $50,000-$100,000 per job to attract large automobile investment.)

Thus, to create a level playing field for investment, more is needed than simple constraining performance requirements. It will also be necessary to limit investment incentives, perhaps as part of an enlarged Subsidies Code. The alternative is to have the world slip steadily in the direction of "investment wars" over the location of multinational corporate production.

Endnote

1. Moran Theodore H. "The Impact of Trade-Related Investment Measures (TRIMs) on Trade and Development: Theory, Evidence, and Policy Implications", A Study prepared for the United Nations Centre on Transnational Corporations, August 1990.

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7

Foreign High-Technology Acquisitions in Canada's Manufacturing Sector

INTRODUCTION

HIGH-TECHNOLOGY INDUSTRIES, requiring a skilled, educated workforce, are generally acknowledged as a means to a vibrant, competitive economy,[1] providing high-paying jobs and rapid growth in employment.[2] Other sectors of the economy are threatened with increasing competition from the newly industrialized countries such as Singapore, Taiwan, Hong Kong and Korea. Together, the attractiveness of high-technology industries and the problems that other sectors face explain why recommendations are made for the transfer of resources from unskilled labour-intensive products and processes to more knowledge-based high-technology activities.[3]

Governments in Canada employ a variety of instruments that directly[4] support and encourage high-technology industries. Outright grants and tax holidays are examples of such instruments. Other instruments have a more indirect impact. The screening of inward foreign investment is one of these. For the purposes of this discussion, inward foreign investment is defined as the acquisition of companies presently operating in Canada or the building of new plant that brings new foreign-owned firms into an industry.

Canada has been actively screening inward investment since the mid-1970s, when the Foreign Investment Review Act (FIRA) was proclaimed. FIRA was subsequently repealed and replaced by the Investment Canada Act in 1985. The latter gives the regulatory body less supervisory authority but still leaves it with responsibility to oversee foreign acquisitions.

If the review of foreign investment is to be used effectively as an instrument of government policy, the motivation behind foreign investment should be understood. Several theories have been used to explain the high level of foreign ownership (particularly by U.S. interests) in Canada.[5] Determining factors in these theories include tariffs, control of scarce resources, and the exertion of monopoly power. Of particular relevance for this paper is the view that foreign firms invest in Canada because they own a technology-based asset, such as a particular technology, that gives them a competitive advantage in Canada. The advantage derives from the fact that the asset is a public good within the firm, since the costs of creating and marketing the asset have already been incurred by the foreign firm elsewhere. As such, exploitation of the asset in Canada requires only the costs of local adaptation.

When the transaction costs of transferring technology from one country to another are sufficiently high, the favoured method of maximizing the value of an asset, usually, is through direct investment abroad rather than through an arm's-length transaction such as a license agreement or sale. Transfer costs are likely to be high where an asset resides in an individual or a team and is not easily transferred from the team to another organization. Appropriability problems may also exist if the asset cannot be easily protected — from imitation, for example — by means of a patent or trademark.

Transfer is perceived to be particularly difficult in a high-technology industry. When the asset is on the leading edge of a technology, problems of appropriability frequently arise. Greater variance in the perceived value of the asset is also likely. This makes it difficult to reach an agreement on the terms and conditions for sale or license. Consistent with this view, recent studies have concluded that the mean age of new technology transferred abroad within a corporation is lower than that transferred under an arm's-length agreement — six to seven years compared to nine to 13 years, depending on the study.[6]

The impact of foreign direct investment in Canada has been the subject of much debate.[7] While there is general agreement that such investment has benefitted Canada, there is also concern that foreign investment, particularly through acquisition, may lead to the "underdevelopment" of the R&D function in Canada. The Task Force on the Structure of Canadian Industry (1968, p. 20) voiced a concern that has subsequently been taken up by other groups:[8]

> "While the ease with which foreign capital could be imported via portfolio and direct investment, skilled manpower via immigration, and technology and entrepreneurship via direct investment has expanded the size and complexity of the economic base and increased opportunities for Canadians, it has, at the same time, diminished the pressures for Canada to develop these skills amongst Canadians to their fullest extent."

According to this view, although foreign direct investment provides Canada with access to a new technology, the R&D function in Canada with respect to that technology is unduly suppressed since it tends to reside in the foreign firm's home country. The Canadian subsidiary is therefore seen to be truncated because this function is absent from its operations.

The screening of inward foreign direct investment is often advocated as an effective way to increase R&D in Canada.[9] Some experts have argued that the review agency should concentrate on providing encouragement to R&D by forcing foreign firms to exploit their technology-based assets through licensing and joint ventures with Canadian-owned firms, rather than through foreign direct investment.[10] Others have argued that the agency is the appropriate instrument to direct the transfer of R&D functions to Canada from the home country of the foreign-owned firm. It has even been suggested that the agency should ensure that the Canadian subsidiary is given a world mandate for a particular product, whereby all the functions associated with the production, marketing and R&D of a particular product would reside in Canada.[11]

Few of these interventionist policies are at present part of the agenda of the existing foreign investment review agency. The role of the agency has changed in the last 20 years. It has been modified from that of a policing body to that of "an investment promotion agency".[12] Nevertheless, it still has the responsibility for overseeing and approving foreign takeovers. Moreover, as the strategic importance of high-technology industries has increased, so too has the pressure for monitoring the effect of foreign acquisitions in the high-technology sector.

Screening of foreign acquisitions in high-technology industries is a form of regulation. Government regulation is appropriate when a perceived problem can be shown to exist and when regulation can be effectively applied. This study attempts to determine whether or not there is a problem. We provide a broad overview of the high-technology sector and of the foreign acquisitions in that sector which is intended to determine whether there is an overriding need for regulation. This paper addresses the following questions.

- Are high-technology industries different from other industries? Do they have characteristics that are considered desirable?
- Would foreign direct investment be expected to be particularly important in such industries? Is it important? What have the trends in foreign direct investment been?
- How important is the acquisition process in bringing foreign firms into Canada and into the high-technology sector in particular? How important is it in relation to other forms of firm entry such as greenfield entry — those that involve the construction of new plant.
- What is the impact of the acquisition process on firms that are acquired? How does it affect productivity, specialization, wages and salaries? Is there any evidence that the impact of foreign direct investment via acquisition is deleterious?

A QUESTION OF DEFINITION: WHAT IS A HIGH-TECHNOLOGY INDUSTRY?

HIGH-TECHNOLOGY MANUFACTURING INDUSTRIES produce goods and/or processes involving the application of science and R&D which are on the frontier of man's knowledge. In some instances, an industry generates the knowledge itself; in others, it incorporates such knowledge in a new product. Descriptions such as "advanced technology", "core technology", "strategic technology" and "leading-edge technology" are all consistent with this general view.

High-technology industries are most often defined in terms of their use of R&D[13] — that is, those industries that use R&D as an input in the production process. R&D use[14] or intensity can be measured in several ways, including the ratio of R&D personnel to employment and R&D expenditures to sales. Such ratios are meant to capture the quantity of technology embodied in the industry's sales. They are also used by governments to set national R&D targets at the level of the economy[15] and the industry.[16]

Despite the widespread use of R&D intensity criteria, there are several practical and conceptual difficulties associated with their application.

- First, there is more than one way to measure R&D intensity. This means that there are several possible indicators to choose from; it also means indicators may be combined as well as used separately.[17] Some of these indicators are not always available at a sufficiently disaggregated industry level to suit the analysis at hand.[18]
- Second, the dividing line between high-technology and "other" industries is not always clear cut.[19] Irrespective of the measuring criteria, industries typically contain a mix of high-technology and other producers.[20]
- Third, for any given set of criteria, the number and identity of high-technology industries may vary through time, thereby complicating inter-temporal study.[21]
- Fourth, high-technology industries can be defined by reference to either national or international R&D intensities. The advantage of international intensities is that they are more likely to reflect the magnitude of the technology embodied in an industry's output. If the R&D function in Canada is truncated, its R&D ratios are not likely to reflect that magnitude.

An OECD study (1986, Table 2.11, p. 59) has defined a set of high-technology industries that overcome some, but not all, of these difficulties. High-technology industries were defined to be those where the R&D expenditure-to-production ratio, across 11 reference countries[22] exceeds four percent. The ten Canadian industries listed in Table 1 were identified as those corresponding most closely to the OECD list. They are used in this study to represent Canadian high-technology industries.[23]

WHAT MAKES HIGH-TECHNOLOGY INDUSTRIES DIFFERENT?

MUCH OF THE INTEREST IN HIGH-TECHNOLOGY INDUSTRIES stems from the appeal of their perceived advantages. They are seen by many as rapid-growth industries and as commanding a high proportion of "good" jobs — two attributes that attract government interest and support. At issue here is the extent to which this is true.

Other characteristics of high-technology industries are also relevant to the debate over the policy problems that are specific to high-technology

TABLE 1

THE HIGH-TECHNOLOGY INDUSTRIES[1]

4-DIGIT SIC CODE	INDUSTRY TITLE
3210	Aircraft & aircraft parts manufacturers
3180	Office & store machinery manufacturers
3340	Manufacturers of household radio & television receivers
3350	Communications equipment manufacturers
3740	Manufacturers of pharmaceuticals and medicines
3911	Instrument & related products manufacturers
3912	Clock & watch manufacturers
3913	Orthopaedic & surgical appliance manufacturers
3914	Ophthalmic goods manufacturers
3360	Manufacturers of electrical industrial equipment

[1] This set is based upon OECD (1986, Table 2.11, p.59) which lists six International Standard Industrial Classification (ISIC) industries as high-technology: aerospace; office machines, computers; electronics and components; drugs; instruments; and electronic machinery. These are defined in more detail in OECD (1984, Table 4, p. 361). These industries are then matched to the 1970 Canadian 4-digit SIC using Dominion Bureau of Statistics (1970) and Baldwin and Gorecki (1986, Table A-2, pp. 210-215).

SOURCE: Baldwin and Gorecki (1986, Table A-2, pp. 210-215); Dominion Bureau of Statistics (1970); OECD (1984, Table 4, p. 361; 1986, Table 2.11, p. 59) and Special Tabulations, Business and Labour Market Analysis, Statistics Canada

industries. Foreign ownership is particularly important because foreign firms often have special advantages in high-technology industries. Frequently, these industries are also highly concentrated. In some quarters, foreign ownership is seen to bolster the anti-competitive effects of a concentrated market.[24] This suggests the possibility that foreign investment might have adverse consequences for competition. Hence, the degree of foreign investment and concentration of firms in high-technology and other industries warrants examination.

Another indicator of the openness to competition is the importance of imports in relation to the size of the Canadian market and exports in relation to Canadian production. Since the OECD has identified trade variables to be important in distinguishing high-technology industries from other industries, both measures of export and import intensity are relevant. To the extent that high-technology industries are more open to international trade than other industries, concerns about competition relating to domestic market structure are less justified.

Five sets of characteristics are employed to contrast high-technology industries with other Canadian manufacturing industries: R&D; foreign ownership; trade and tariffs; the size distribution of firms; and growth and jobs. Table 2 contains summary statistics for each of these characteristics and tests the null hypothesis that the mean for each characteristic, across the two groups of industries, is the same.[25]

TABLE 2

STRUCTURAL CHARACTERISTICS OF HIGH-TECHNOLOGY AND OTHER INDUSTRIES IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979

STRUCTURAL CHARACTERISTICS	INDUSTRY GROUPING[1] HIGH-TECHNOLOGY	OTHER	HYPOTHESIS: THE MEANS ARE EQUAL[12]
	Mean (Standard Error of Mean)		
	R&D characteristics[2]		
1. R&D to sales ratio[3] (%)	2.71	0.21	rejected
	(0.95)	(0.03)	(0.05)
2. Technology payments to sales ratio[4] (%)	1.67	0.05	not rejected
	(0.95)	(0.01)	
	Foreign Ownership Characteristics		
3. Proportion of industry shipments accounted for by foreign controlled[5] firms (%)			
1970	82.74	42.76	rejected
	(4.23)	(2.36)	(.01)
1979	70.20	39.70	rejected
	(6.43)	(2.32)	(.01)
	Trade and Tariff Characteristics[6]		
4. Imports as a proportion of domestic disappearance (%)			
1970	42.35	18.84	rejected
	(6.53)	(1.54)	(.01)
1979	59.22	26.84	rejected
	(7.51)	(7.42)	(.01)
5. Exports as a proportion of domestic production (%)			
1970	18.41	13.67	not rejected
	(4.97)	(1.77)	
1979	34.16	17.90	not rejected
	(8.25)	(2.59)	
6. Nominal tariff protection (%)			
1970	7.41	11.97	rejected
	(1.02)	(1.18)	(.01)
1978	6.30	10.36	rejected
	(8.33)	(0.68)	(.01)
	Firm Size Distribution Characteristics		
7. The Herfindahl Index of concentration[7]			
1970	0.1693	0.1119	rejected
	(0.0288)	(0.0076)	(.10)
1979	0.1575	0.1120	not rejected
	(0.0216)	(0.0091)	

TABLE 2 (continued)

STRUCTURAL CHARACTERISTICS	INDUSTRY GROUPING[1]		HYPOTHESIS: THE MEANS ARE EQUAL[12]
	HIGH-TECHNOLOGY	OTHER	
Growth and Job Characteristics			
8. Annual industry growth rate (%)			
1) unweighted, annual, 1970-79[8]	4.23 (1.48)	2.39 (0.26)	rejected (.10)
2) weighted, cumulative 1970-79[9]	37.0	45.0	not tested
9. Average Annual Income ($000's)[10]			
a) Production worker			
1970	5.861 (0.278)	5.832 (0.112)	not rejected
1979	13.354 (0.544)	13.915 (0.262)	not rejected
b) Salaried worker			
1970	8.944 (0.296)	8.474 (0.081)	not rejected
1979	19.072 (0.391)	19.061 (0.195)	not rejected
c) All workers			
1970	6.998 (0.334)	6.389 (0.108)	not rejected
1979	15.162 (0.591)	14.897 (0.251)	not rejected
10. White-collar jobs as a proportion of industry employment[11] (%)			
1970	36.18 (3.26)	22.96 (0.78)	rejected (.01)
1979	31.92 (3.15)	21.03 (0.73)	rejected (.01)

1. See Table 1 for the identity of the high-technology industries. The other industries are the 167 4-digit industries into which the manufacturing sector is divided, less the ten high-technology industries. Since one variable could not be calculated, the total number for the set of other industries was generally 156, not 157. However, in some instances, slightly different sample sizes are used. See notes for details.
2. Technology characteristics are the mean of the given ratio for 1975 and 1979. The R&D ratios were available at the 3-digit level and then spread to the 4-digit level — the level of aggregation at which acquisition and other industry characteristics are available. Full details of how these R&D data are constructed may be found in Statistics Canada (1984), while Baldwin and Gorecki (1986, Table A-2, pp. 210-215) contains the 3- and 4-digit industry classification systems used herein.
3. R&D is measured as current intramural expenditures on R&D.
4. Payments made outside of Canada for R&D and other technology (net of withholding taxes).
5. A firm is defined as foreign-controlled if there is effective foreign control, although the foreign corporation may own less than 50 percent of the stock. Of the high-technology set of industries, no published data is available for SIC = 3194 for 1970 due to confidentiality requirements of the Statistics Act. Hence, for both 1970 and 1979, the importance of foreign ownership is estimated across nine, not all ten, of the high-technology industries. The impact of this omission is to bias upward the importance of foreign ownership. In 1979, for example, with all ten high-technology industries included, the importance of foreign ownership declines from 70.20 percent to 66.06 percent.
6. For more details of the procedure used to define the tariff and trade variables, see Baldwin and Gorecki (1986, Appendix A, pp. 172-182).
7. The Herfindahl index of concentration is defined as the sum of squares of the market share held by each firm. It will vary between 1 (the industry contains a single firm) and 1/N, where N is the number of firms, all of which are of equal size.
8. Annual growth rate of value of shipments in real terms, 1970- 1979. For derivation, see Baldwin and Gorecki, 1986.
9. The rates of 1979 shipments divided by 1970 shipments (both measured in 1979 dollars) minus 1 and weighted by 1970 value of shipments when the weighted mean is calculated.
10. Income refers to gross earnings of workers from salaries and wages before deductions of any kind, such as income tax, unemployment insurance and pension benefits. Note that workers are defined in person-year equivalents. For further details see Statistics Canada (1979, p.26) and the next note.
11. The percentage of total industry employment (production plus salaried workers) accounted for by salaried workers. The latter are sometimes referred to as non-production workers. For details of this distinction between production and salaried workers, see Statistics Canada (1979, pp. 23-24).
12. The procedure employed computed t- statistics for the hypothesis that the means of the high-technology and other industries were equal. Account was taken of whether or not the variances were equal.

SOURCE: Special Tabulations, Business and Labour Market Analysis, Statistics Canada

As expected, the mean of R&D intensity is greater for the high-technology industries (2.7 percent of sales) than for other industries (0.2 percent). Nevertheless, the level of R&D in high-technology industries is below the four percent cut-off point used by the OECD. It can be argued, therefore, that Canada does not have a high-technology sector that makes much use of the results of R&D. That would be incorrect.

A more complete picture would take into account technological payments made outside Canada for R&D and other technology in measuring the amount of technology embodied in an industry's output. Foreign ownership of Canadian manufacturing industries — particularly high-technology industries — is important and foreign firms are more likely to import technology. Table 2 is consistent with this view. If payments for technology made outside Canada are added to the cost of R&D conducted in Canada, then the mean R&D level rises to 4.4 percent of sales in high-technology industries and 0.3 percent in other industries.[26]

Also as expected, the mean level of foreign ownership is significantly higher for high-technology industries than in other industries. In 1970, foreign-controlled firms accounted for about 80 percent of the products shipped by high-technology industries, but only 42 percent in other industries. During the 1970s foreign ownership declined by more than 10 percentage points in the high-technology group; the decline was only three percentage points in other industries. This pattern continued into the eighties. By 1986 the level for the high-technology set had fallen to 65 percent; for other industries the level reached 36 percent.

In summary, during the period 1970 - 86, foreign ownership in Canada's manufacturing sector declined irrespective of the technological intensity of the industry. However, the rate of decline was highest in the high-technology sector.

The panel of trade and tariff characteristics shown in Table 2 is consistent with the OECD (1986) results. Trade was found to be more important in high-technology industries than in other manufacturing industries. In 1979, the average import and export intensity ratios for high-technology industries were twice those of low-technology industries. The import and export intensities in 1979 reflected, in part, the much larger increase in intra-industry trade over the decade in high-technology industries. Consistent with this pattern were the substantially lower tariffs in high-technology industries.

The characteristics of the size distribution of firms in Table 2 show that high-technology industries are more concentrated than other industries. The degree to which industry output is controlled by a small number of producers is indicated by the Herfindahl index — which shows that the level of control by a small number of producers is much higher in high-technology industries than in other industries.[27]

The final set of industry characteristics refers to growth rates and the nature of the jobs created, since high-technology industries are frequently thought of as providing good jobs and having high growth rates. The results shown in Table 2 do not support this characterization of high-technology industries.

The evidence as to growth rates suggests that high-technology industries in Canada are not the engines of change, even though they may be so elsewhere. If growth is calculated on the basis of annual change(s) over the decade, the simple mean growth rate of the high-technology industries (4.23) is higher than that of other industries (2.39). However, annual averages include large swings in growth rates and annual growth rates in the high-technology sector show much greater variance than in other industries. Moreover, growth was not spread evenly over all high-technology industries. The largest high-technology industries experienced lower growth rates than smaller high-technology industries. As a result, the cumulative effect of change over the 1970s on the high-technology sector was less than in other industries. When growth rates in the real value of product shipments are weighted by size of industry,[28] the mean cumulative growth rate in the high-technology sector was only 37 percent; it was 45 percent for all other industries.

Two indicators of job quality are shown in Table 2 — the share of white-collar workers in industry employment, and the annual incomes of production and salaried workers. High-technology industries recorded a higher percentage of total jobs in the white-collar category compared to other industries. However, the incomes of production and salaried workers in high-technology industries were similar to those in other industries.[29] In 1979, for example, the average annual income of a salaried employee in a high-technology industry exceeded that of comparable employees in other industries by (only) $11, but was $561 *lower* for a production worker.[30]

Unless high-technology jobs are somehow themselves inherently more pleasant or have greater security, this suggests that the benefits which are sometimes assumed to be associated with high-technology industries are not captured by labour.[31]

In summary, high-technology industries do exhibit several of the characteristics that have caused them to receive special attention compared to other manufacturing industries: R&D intensity is higher; foreign ownership is greater; openness to foreign competition is more marked; white-collar jobs are more prevalent; and concentration is somewhat higher. However, not all of the *a priori* expectations were confirmed. Growth rates were not generally higher and incomes of production and salaried workers were not noticeably different in high-technology than in other industries. High-technology industries in Canada would appear, therefore, not to be the engine of high income jobs, although a higher percentage of employment therein was in the white-collar category.

CHARACTERISTICS OF FOREIGN AND DOMESTIC FIRMS

WHILE THE CHARACTERISTICS of high- and low-technology industries differ in some important respects, those differences by themselves do not justify restricting the focus of a regulatory review process to the performance of foreign acquisitions in this sector compared to other sectors. This requires

TABLE 3

THE RATIO OF SELECTED CHARACTERISTICS OF FOREIGN TO CANADIAN-OWNED PLANTS, ACROSS HIGH-TECHNOLOGY AND OTHER INDUSTRIES[1] CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979

	INDUSTRY GROUPING	
CHARACTERISTICS	HIGH-TECHNOLOGY	OTHER
	Mean Ratio of Foreign to Canadian-Owned Plants[2] (Standard Error of Mean)	
Firm Specialization[3]		
1970	0.81	0.79
	(.031)	(.025)
1979	0.83	0.80
	(.027)	(.020)
Plant Specialization[4]		
1970	1.36	1.17
	(.161)	(.037)
1979	1.27	1.17
	(.112)	(.032)
Labour Productivity		
a) Value Added per Employee[5]		
1970	1.27	1.31
	(.110)	(.032)
1979	1.27	1.42
	(.071)	(.040)
b) Shipments per Employee[5]		
1970	1.54	1.32
	(.253)	(.039)
1979	1.26	1.44
	(.093)	(.071)
Annual Average Income[6]		
a) Production Worker		
1970	1.04	1.11
	(.044)	(.012)
1979	0.99	1.08
	(.051)	(.012)
b) Salaried Worker		
1970	1.05	1.10
	(.042)	(.011)
1979	1.02	1.00
	(.032)	(.017)

TABLE 3 *continued*

	INDUSTRY GROUPING	
CHARACTERISTICS	**HIGH-TECHNOLOGY**	**OTHER**
White-collar jobs as a proportion of industry employment[7]		
1970	1.17	1.18
	(.162)	(.029)
1979	1.07	1.20
	(.110)	(.033)

[1] The definition of the industry groups is found in note 1, Table 2.

[2] The ratios were calculated by taking the mean value of a characteristic for foreign and domestic plants in each 4-digit industry and dividing the former by the latter, then taking the average across all 4-digit industries in the particular industry grouping.

[3] Firm specialization is the Herfindahl Index of the parent organization's specialization across all 4-digit industries in manufacturing, mining and logging.

[4] Plant specialization is the Herfindahl Index of plant shipments at the 4-digit ICC commodity level. There are 2,336 4-digit ICC commodities. Details of the calculation of the Herfindahl Index at the plant level are found in Baldwin and Gorecki (1986, p. 179).

[5] Total employment is defined as all production and salaried workers.

[6] See note 10 to Table 2.

[7] See note 11 to Table 2.

SOURCE: Special Tabulations, Business and Labour Market Analysis, Statistics Canada

information on how foreign firms differ from domestic firms in the high-technology sector and whether these differences are the same as in other sectors. To this end, certain characteristics of foreign and domestic firms are compared in high-technology and other industries.

The characteristics considered here are: the degree of firm and plant specialization; labour productivity; incomes of production and salaried workers; and the share of white-collar jobs in industry employment.

For each industry, the ratio of the mean value of each characteristic for all foreign-owned plants was divided by the mean for all Canadian-owned plants. Table 3 shows the mean value of this ratio, calculated separately across all the high-technology and other industries for which there were observations. The standard error of each mean value appears in brackets.

For the industries studied, the parent organizations of foreign-owned plants[12] were more diversified across industries than the parent organizations of domestically owned plants. Within each industry, foreign-owned plants were more specialized. Foreign-owned plants were more productive, but their employees (both production and salaried workers) earned much the same as those employed by domestically owned firms. Finally, foreign-owned plants tended to have a higher proportion of their total workforce classified as white-collar workers.

TABLE 4

RESULTS OF THE REGRESSION[1] OF PLANT CHARACTERTERICS ON INDUSTRY AND OWNERSHIP DUMMY VARIABLES, CANADIAN MANUFACTURING SECTOR, 1979

	CHARACTERISTIC[2]				
				ANNUAL AVERAGE INCOME	
DUMMY VARIABLES	FIRM SPECIALIZATION	PLANT SPECIALIZATION	LABOUR PRODUCTIVITY	PRODUCTION WORKER	SALARIED WORKER
DOM	+*	-*	-*	-*	-*
HITECH	+*	-*	-*	-*	-
DOM HITECH	–*	+*	+*	+*	+
NET	+*	+*	-*	0	+

[1]A separate regression was estimated for each plant characteristic. The independent variables were: DOM = 1, when the plant is domestically owned, zero otherwise; HITECH = 1, when the industry to which the plant is classified is high-technology, zero otherwise; and the product of DOM and HITECH. NET is the net effect of being a domestic plant in a high-technology industry (i.e., DOM + DOM. HITECH). The regression was estimated across all plants for 1979 in the Canadian manufacturing sector.

[2]The characteristics are defined in Table 3. Labour productivity is measured as value added per worker.

* Significant at the 1 percent level.

SOURCE: Special Tabulations, Business and Labour Market Analysis Group, Statistics Canada

The difference between foreign- and Canadian-owned plants in the high-technology sector compared to all other industries depicted in Table 3 is not large. In order to provide a more precise test and to distinguish both industry and ownership effects simultaneously, the characteristics of all plants were, separately, regressed on binary variables representing: the domestic ownership of the plant (DOM) and whether it was in a high-technology industry (HITECH). An interactive variable (DOM.HITECH) was used to capture the additional advantage/disadvantage experienced by domestic plants in high-technology industries. The signs and significance of the resulting coefficient estimates are shown in Table 4, along with the net effect of being a domestic firm in a high-technology industry (NET).

In general, domestically owned plants compared to foreign-owned plants were part of a parent organization that was itself more specialized in terms of the industries in which they owned plants, but were less specialized in terms of the products they produced, had lower productivity, and paid lower production wages and salaries. On the other hand, domestically owned plants in high-technology industries were more specialized and belonged to parent organizations that were more diversified than their domestic counterparts in other industries. They experienced a lower productivity disadvantage, though on net they were still significantly less productive than foreign plants. The annual production worker income differential between domestic and foreign plants was also lower in high-technology industries and not significantly different from zero. There was no significant differential in salary income.[33]

The conclusion to be drawn from this data is that there is less difference between foreign and domestic plants in high-technology industries in Canada than there is in other industries.

DIVESTITURES AND ACQUISITIONS IN HIGH-TECHNOLOGY INDUSTRIES

THE ROLE OF THE AGENCY RESPONSIBLE for screening acquisitions in high-technology industries depends not only on the importance of acquisitions in this area, but also on the incidence of other forms of firm turnover — the change in the identity and market share of firms in an industry — that lead to industry renewal and growth. Foreign firms can enter an industry not only by acquisition but also by building new plant (greenfield entry). If acquisition and divestiture by foreign interests are the dominant methods of firm turnover in high-technology industries, then the role for the screening agency will be substantial because the potential effect (beneficial or otherwise) will be large. On the other hand, if plant acquisition is relatively unimportant because the incidence of foreign acquisition is low compared to other methods of firm turnover, then the role for a screening agency that concentrates on acquisitions will be more limited. Other, more appropriate, policy instruments will be required to control foreign ownership in high-technology industries.

An understanding of the importance of the various components of the turnover process is required for an even more fundamental reason. Firm turnover implies change. Change means that plans are often not realized. Where this is prevalent, it is difficult for governments to extract concessions from firms — for several reasons. First, when a firm changes hands, the associated administrative costs of monitoring, notification, negotiation and approval of the original agreement are usually high. Second, in industries where it is normal for firms to gain or to lose large amounts of market share, it is difficult to predict success and, therefore, to forecast the profit potential or rent that can be extracted from an entrant by a monitoring agency. This means that agreements between the regulatory agency and acquiring firms must be subsequently modified, thereby increasing administrative costs even further.

The process of firm turnover in Canada's manufacturing sector during the 1970s can be readily quantified by using a database created at Statistics Canada that draws on information supplied by the Census of Manufactures.[34] By means of unique identifiers, individual firms and plants can be tracked through time.

Several categories of firm turnover were chosen for analysis here:

1) acquisitions and divestitures that bring new firms into an industry (acquisition entries) or are associated with firms leaving an industry (divestiture exits);

2) entries via plant openings (greenfield entrants) and firms that exit because of plant closings (closedown exits);
3) plant openings and closings by continuing or incumbent firms.

Acquisitions and divestitures include plants that existed in both 1970 and 1979, but which experienced a change in ownership or corporate control during the period resulting in the entry or exit of a firm.[35] Openings and closures include new plant openings and those shut down, in particular 4-digit SIC industries. Closures include plants that existed in 1970, but not in 1979; openings include plants that existed in 1979, but not in 1970. Closures, therefore, include all plants from the 1970 population that exited during any one of the next nine years; openings include all plants in the 1979 population that were established during any one of the previous nine years. It is the *cumulative* impact of entry and exit over the 1970s, not the transitory or short-term impact, that is measured here.[36]

While there are other aspects of firm turnover, such as horizontal mergers and growth and decline in the incumbent sector, it is the entry process (particularly through acquisition) that is the focal point for intervention by the foreign investment review agency and, therefore, the focus of this study.

THE IMPORTANCE OF HIGH-TECHNOLOGY INDUSTRIES IN THE FIRM TURNOVER PROCESS

IN CHARACTERIZING THE FIRM TURNOVER PROCESS, the first issue is the extent to which high-technology industries account for a significant proportion of *all* acquisitions and divestitures, and openings and closings in the manufacturing sector. The relative importance of acquisitions (or openings, or divestitures, or closings) in the high-technology sector is measured by calculating the ratio of the output of all plants falling in one of these categories in the high-technology sector to the output of all plants affected the same category (acquisitions, or openings, or divestitures, or closings) in all industries. Output here is measured in terms of value added — sales less intermediate inputs such as raw materials and energy. The distribution of value added for each turnover category across the high-technology and other industry groupings as well as the distribution of manufacturing sector value added is shown in Table 5.

The extent to which high-technology industries account for plant acquisitions and divestitures, and openings and closings, is about what might be expected on the basis of their share of manufacturing sector value added. It is generally somewhat less in the case of firm entry and exit; somewhat more for continuing firms.[37] For example, in 1979 high-technology industries accounted for 7.8 percent of manufacturing sector value added, but 6.7 percent and 10.9 percent of the value added involved in plant openings by entering and continuing firms, respectively.

From this data we conclude that turnover is neither inordinately high nor low in high-technology industries relative to other industries.[38]

TABLE 5

THE DISTRIBUTION BY VALUE ADDED OF PLANT DIVESTITURES, ACQUISITIONS, CLOSURES AND OPENINGS IN HIGH-TECHNOLOGY AND OTHER INDUSTRIES, CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979

	INDUSTRY GROUPING		
PLANT/FIRM CATEGORY	**HIGH-TECHNOLOGY[1]**	**OTHER[2]**	**TOTAL**
	Distribution of Value Added in Each Category[3]		
Plant Divestitures[4]			
Exiting Firms	8.28	91.72	100
Continuing Firms	13.97	86.03	100
Plant Closures[5]			
Exiting Firms	7.08	92.92	100
Continuing Firms	14.01	85.99	100
Industry Value Added			
1970	9.29	90.71	100
Plant Acquisitions[6]			
Entering Firms	10.81	89.19	100
Continuing Firms	1.75	98.25	100
Plant Openings[7]			
Entering Firms	6.66	93.34	100
Continuing Firms	10.93	89.07	100
Industry Value Added			
1979	7.84	92.16	100

1. See Table 1 for a list of the 10 high-technology industries.
2. The other industries are the 167 4-digit industries into which the manufacturing sector is divided less the high-technology industries. Since one of the characteristics in Table 2 could not be calculated for this set of industries the set is 156 rather than 157.
3. Divestitures and closures refer to the distribution of value added as of 1970; acquisitions and openings as of 1979.
4. Divestitures refer to plants that were classified to the industry in both 1970 and 1979, but owned by a different firm in 1970 and 1979. In some instances, the owning firm no longer existed in 1979, (exiting firms); in others, it still existed in 1979 (continuing firms).
5. Closures refer to plants that were classified to the industry in 1970 but not 1979. In some instances, the owning firm no longer existed in 1979 (exiting firm); in others, it continued to exist in 1979 (continuing firms).
6. Acquisitions refer to plants that were classified as part of the industry in 1970 and 1979, but were owned in 1979 by a new firm (entering firms); in others, a firm that existed in 1970 and 1979 in the industry (a continuing firm).
7. Openings refer to plants that were classified as part of the industry in 1979, but not in 1970. In some circumstances, the owning firm did not exist in the industry in 1970, but did in 1979 (entering firms); in others, it existed in both years (continuing firms).

SOURCE: Special Tabulations, Business and Labour Markets Analysis Group, Statistics Canada

The role of foreign firms in the turnover process is further explored in Table 6. The percentage of value added accounted for by foreign firms in each turnover category is shown along with the percentage of overall industry value added in each industry group (also accounted for by foreign firms). Thus, of

TABLE 6

THE DISTRIBUTION OF PLANT DIVESTITURES, ACQUISTIONS, CLOSURES AND OPENINGS ACCOUNTED FOR BY FOREIGN-CONTROLLED FIRMS, ACROSS HIGH-TECHNOLOGY AND OTHER INDUSTRIES, BY VALUE ADDED[1] IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979[2]

PLANT/FIRM CATEGORY	INDUSTRY GROUPING HIGH-TECHNOLOGY	INDUSTRY GROUPING OTHER
	Proportion Foreign-controlled (%)	
Plant Divestitures		
Exiting Firms	78.74	37.54
Continuing Firms	100.0	63.99
Plant Closures		
Exiting Firms	75.61	29.30
Continuing Firms	47.88	62.08
Industry Value Added 1970	81.64	49.03
Plant Acquisitions		
Entering Firms	50.09	42.02
Continuing Firms	91.84	27.96
Plant Openings		
Entering Firms	46.58	28.14
Continuing Firms	56.73	56.43
Industry Value Added 1979	69.85	45.65

1. The industry value added ratios are weighted averages taken across all industries in a group.
2. The industry groupings and plant/firm categories are defined in the notes to Table 5.

SOURCE: Special Tabulations, Business and Labour Markets Analysis Group, Statistics Canada

the value added of plant acquisitions by entering firms in high-technology industries, 50.1 percent was accounted for by foreign entering firms while foreign firms in total accounted for 69.9 percent of total value added in high-technology industries.

The firm turnover process in high-technology industries is dominated by foreign-owned firms. Their activities are not confined simply to plant acquisitions and divestitures; they also play an important role with respect to plant openings and closings. However, foreign-owned firms tend to be less important with respect to plant acquisitions and openings by entering firms (compared to plant divestitures and closures by exiting firms) reflecting the decline in the importance of foreign ownership in high-technology industries in the 1970s. By contrast, in other industries, foreign firms play a much less important role.

These results are not altogether surprising, in view of the difference in the importance of foreign and domestic firms across these two groups of industries.

THE INTENSITY OF THE FIRM TURNOVER PROCESS IN HIGH-TECHNOLOGY INDUSTRIES

THE ANALYSIS OF THE DISTRIBUTION of the turnover process to this point does not reveal the intensity of the different components of the turnover process. In this section, we consider intensity (of turnover) by asking the following questions:

- what percentage of industry shipments are accounted for by acquisitions and divestitures, plant openings and closings?
- are there important differences in the intensity of turnover between high-technology and other industries?
- do foreign firms play different roles in the various plant/firm categories measuring the intensity of turnover and/or between high-technology and other industries?

Table 7 provides a broad overview of the components of the turnover process. As a summary measure, the average share gained and lost for firms in each of three categories is given. There are two entry and exit categories. Greenfield entry and closedown exit is covered in row 1. Acquisition entry and divestiture exit is presented in row 3. For these categories, the summary measure of turnover is calculated as one-half the sum of the market share of entries in 1979 plus the market share of exits in 1970. It provides an approximation to the amount of market share being shifted by that particular component in the turnover process. In addition, the average share transferred among continuing firms as a result of market share gain and decline is given in row 2.[39] This is one-half of the market share gains plus market share losses between 1970 and 1979 of continuing firms. Once more, it approximates the turnover caused by this category.[40]

Previous research has determined that a considerable portion of total market share was transferred as a result of both entry and exit, as well as growth and decline in incumbents in the Canadian manufacturing sector between 1970 and 1979. These results are mirrored for the "other" industry category, which covers most of the manufacturing sector. Together, greenfield entry and closedown exit, and growth and decline in the continuing sector (rows 1 and 2) transferred 36 percent of market share from losers to gainers. This is not much different from the high-technology industries, where approximately 35 percent of market share was transferred.

Most examinations of entry and exit consider only greenfield entry or closedown exit. However, the merger process that brings firms into and takes them out of an industry has been shown elsewhere to be important too.[41] This is confirmed in Table 7 for both industry groupings (row 3). The amount of market

TABLE 7

FIRM TURNOVER MEASURES ACROSS HIGH-TECHNOLOGY AND OTHER INDUSTRIES IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979[1]

	INDUSTRY GROUPING	
PLANT/FIRM CATEGORY	HIGH-TECHNOLOGY	OTHER
	Average Market Share Transferred (Standard Error of Mean)	
1) Plant Opening and Closing by Entering and Exiting Firms[2]	19.6	20.1
	(4.7)	(1.1)
2) Growth and Decline of Continuing Firms[3]	15.4	16.1
	(2.0)	(0.4)
3) Plant Acquisitions and Divestitures by Entrants[4] and Exiting Firms	8.1	10.3
	(2.9)	(1.1)
4) Total turnover[5]	41.8	44.3
	(4.0)	(1.3)

[1] Industry groupings and the plant/firm categories are defined in the notes to Table 5.

[2] Firm turnover due to entry and exit is one-half the sum of the absolute value of share change due greenfield entry plus closedown exit.

[3] Firm turnover in the continuing sector is one-half the sum of the absolute value of share change between 1970 and 1979 of incumbents. For this calculation, firms that were acquired by entrants or divested by exits were considered as ongoing entities.

[4] Firm turnover due to the merger process is one-half the sum of the absolute value of the market share due to acquisition entry plus divestiture exit.

[5] Total turnover is one-half the sum of the absolute value of all share change, where acquisition entrants and divestiture exits are included as entry and exits rather than as ongoing entities.

SOURCE: Special Tabulations, Business and Labour Market Analysis Group, Statistics Canada

share being transferred as a result of acquisition entry and divestiture exit in high-technology industries is 8.1 percent; 10.3 percent in other industries. This is only about half as much as the results shown for the other two components.

Together, the three categories in Table 7 show that turnover transferred a substantial amount of market share over the decade from one group of firms to another. The three rows, however, cannot be combined to provide a single overall measure of turnover because that would involve some double counting. The market share turnover in plants acquired and divested is already included in row 2 since, for these calculations, these plants are considered as ongoing entities. The final row of Table 7 provides a summary of the total share being shifted without double-counting acquisitions and divestitures.[42] In total, 44.3 percent of market share was transferred in other industries and 41.8 percent was transferred in high-technology industries. The differences between the two do not appear to be meaningful in economic terms.

TABLE 8

THE SHARE OF INDUSTRY SHIPMENTS ACCOUNTED FOR BY DIVERTITURES, ACQUISITIONS, CLOSURES AND OPENINGS, HIGH-TECHNOLOGY AND OTHER INDUSTRIES IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979[1]

	INDUSTRY GROUPING	
SHARE OF INDUSTRY SHIPMENTS ACCOUNTED FOR BY VARIOUS PLANT/FIRM CATEGORIES	HIGH-TECHNOLOGY	OTHER
	Mean Market Share[2] (Standard Error of Mean)	
Plant Divestitures		
Exiting Firms	8.7	13.0
	(2.9)	(1.0)
Plant Closures		
Exiting Firms	17.8	18.2
	(6.6)	(1.2)
Continuing Firms	4.8	4.6
	(2.4)	(0.5)
Total	22.6	22.8
	(6.2)	(1.2)
Plant Acquisitions		
Entering Firms	9.4	10.8
	(2.8)	(1.0)
Plant Openings		
Entering Firms	17.6	16.1
	(3.8)	(1.2)
Continuing Firms	5.8	5.2
	(1.8)	(0.5)
Total	23.3	21.2
	(3.6)	(1.2)

1. The industry groupings and plant/firm categories are defined in the notes to Table 5.
2. The mean of the share of each plant/firm category for each industry grouping.

SOURCE: Special Tabulations, Business and Labour Market Analysis, Statistics Canada.

Table 8 draws a more disaggregated picture of the firm turnover process by showing rates of entry and exit for various plant/firm categories for high-technology and other industries. The data show considerable similarity in the pattern and importance of entry and exit rates across high-technology and other industries. The plant closure rate and the plant opening rate for entrants and exits across the two industry groupings varied only between 16.1 percent and 18.2 percent. There were differences, however, with respect to entries via acquisitions

TABLE 9

Changes In Market Share in the Foreign and Domestic Sectors from Entry and Exit, High-Technology Industries in the Canadian Manufacturing Sector from 1970 to 1979

PLANT/FIRM CATEGORY SHARE, 1970[1]	MEAN MARKET SHARE, 1979[2] (%)	PLANT/FIRM CATEGORY	MEAN MARKET SHARE, 1979-1970 (%)	NET CHANGE IN MARKET SHARE, 1979-1970
Panel A: Foreign Sector				
Plant Closures		*Plant Openings*		
Exiting Firms	14.4	Entering Firms	7.3	-6.6
Continuing Firms	3.2	Continuing Firms	3.7	
Plant Divestitures by Exiting Firms		*Plant Acquisitions by Entering Firms*		
To Domestic Firms	1.93	From Domestic Firms	1.14	-0.79
To Foreign Firms	4.83	From Foreign Firms	4.99	
Panel B: Domestic Sector				
Plant Closures		*Plant Openings*		
Exiting Firms	3.5	Entering Firms	10.3	+7.3
Continuing Firms	1.6	Continuing Firms	2.1	
Plant Divestitures by Exiting Firms		*Plant Acquisitions by Entering Firms*		
To Domestic Firms	0.95	From Domestic Firms	0.89	
To Foreign Firms	0.94	From Foreign Firms	2.40	+1.46

1. The plant/firm categories are defined in the notes to Table 5, the high-technology industries in Table 1.
2. The mean of the share for each plant/firm category. Market share is measured in shipments.

Source: Special Tabulations, Business Market and Labour Analysis Group, Statistics Canada

and exits via divestitures. These rates were lower (particularly for divestitures) in high-technology than in other industries. Thus, where foreign ownership declined most dramatically, entries and exits via plant openings and closings were more intense relative to entries and exits via plant acquisitions and divestitures.

THE EFFECT OF THE FIRM TURNOVER PROCESS ON FOREIGN AND DOMESTIC OWNERSHIP IN HIGH-TECHNOLOGY INDUSTRIES

THE CHANGES IN THE MARKET SHARE of foreign- and domestically owned firms in high-technology industries due to various firm turnover categories are summarized in Table 9. The categories of market share turnover are those identified earlier. Plant closures and divestitures refer to market shares as of 1970; plant openings and acquisitions to 1979. The net effect of plant turnover on foreign and domestic market share is shown in the last column of Table 9.

Plant openings and closings in the foreign sector contributed, on balance, to lower foreign ownership. The market share of plants created by new and continuing foreign firms was 6.6 percent less than the market share of plants closed by exiting and continuing foreign firms. On the other hand, the effect of plant entry and exit in the domestic sector was to increase its market share. There the market share of new plants was 7.3 percent more than the market share of plants closed.

The net contribution of the divestiture of foreign plant to domestic firms and the acquisition of plants by foreign firms from domestic firms was a decline of 0.8 percent in the market share of the foreign sector. Acquisition and divestiture between the domestic and foreign sectors contributed an increase in market share of 1.5 percent to the domestic sector. As previously noted, in high-technology industries the share of foreign ownership fell by about 10 percent in the 1970s. It is evident that most of the decline in the foreign sector and the growth in the domestic sector was the result of a difference between plant closures and openings. The remainder was due to foreign firms losing market share to domestic firms.

THE IMPACT OF ACQUISITIONS AND DIVESTITURES

THE HIGH LEVEL OF TURNOVER IN BOTH HIGH-TECHNOLOGY and other industries attests to the pervasiveness of competition in the Canadian manufacturing sector. Although some of the components of turnover vary across industries,[43] high-technology industries are not, on average, appreciably different from other industries in terms of the intensity of market share turnover. While foreign ownership and, to a lesser extent, concentration are greater in high-technology than other industries, differences in the volume of turnover do not suggest that the combination of concentration and foreign ownership has led to any significant reduction in the effects of the competitive process — at least not if competition is measured (as it is here) in terms of the outcome of the battle for market share, rather than against a structural characteristic such as concentration.[44]

The merger process must, however, be considered in a broader context because there is a substantial body of literature (drawn largely from American sources) arguing that mergers involve a churning of resources which, at best, has inconsequential effects and, at worst, is detrimental to the allocation of resources. Many such studies conclude that mergers are failures.[45] Some Canadian studies associated with the Royal Commission on Corporate Concentration (1978) found similar results for Canada. It should be noted, however, that not all studies have found these negative results. A number of event studies that are based on stock market data have found positive effects of mergers — for the shareholders of acquired firms in the United States and for shareholders of both acquired and acquiring firms in Canada.[46]

The desirability of a regulatory policy to oversee foreign acquisitions depends largely on the costs and benefits associated with interference with the market for corporate control. If that market does little to improve the allocation of resources, interference may inflict little damage. On the other hand, when mergers have a potentially significant effect, the case for regulation must meet more rigorous standards.

Very little study has been devoted to the effects of mergers — especially foreign mergers — in Canada. Therefore, this study breaks new ground in trying to provide a broad overview of the effects of mergers in the high-technology sector. The importance of the turnover process is measured by its impact on size, productivity growth and the change in worker remuneration. While this list of attributes is not comprehensive, it at least starts the process by making use of some of the characteristics that should be examined.[47] An evaluation of the effects of mergers does not have to rely just on theorizing when data is available to measure those effects.

In previous research (Baldwin & Gorecki, 1991a) we investigated the contribution of turnover to productivity growth in the manufacturing sector as a whole during the 1970s. We found closedown exits were less productive than average in 1970; greenfield entries were more productive than average in 1979. Plants closed by continuing firms showed average productivity in 1970, but new plants opened by incumbent firms recorded much higher results than average in 1979. Finally, those continuing plants that gained market share over the decade became about one-third more productive by 1979 than those that lost market share over the decade. There was no significant difference between the two groups in 1970.

The replacement of closedown exits and declining firms by greenfield entries and growing firms contributed to productivity growth during the decade. Estimates of the contribution made to the increase in real output per worker suggest that about half this growth was due to market share turnover.

Not all turnover is associated with plant openings and closures. A large amount of market share is also transferred as a result of changes in ownership associated with acquisition entry and divestiture exit. The extent to which this has demonstrable effects on productivity has been investigated in Baldwin and Gorecki (1990c). In the short run, such mergers had a positive effect on both market share and productivity. In the long run, both effects are more difficult to discern. On average, acquisitions associated with entry and divestitures associated with exit slightly increased output per worker; these had a much greater effect on profitability. These are important in that they correspond to results emerging from the use of similar longitudinal data bases for the U.S. manufacturing sector.[48] Equally important, they do *not* support the claim made by some American studies that merger activity has significant deleterious consequences.

In order to determine the effect of turnover in the high-technology sector we compared the characteristics of acquisitions and divestitures in both high-technology and other industries. These characteristics included plant specialization, parent diversification, size, labour productivity, production and salary worker income, and the share of white-collar workers in industry employment. A comparison of the 1970 and 1979 characteristics of plants that experienced control change sometime during this period allows inferences about the effect of the mergers to be drawn. A comparison of the characteristics of plants acquired and divested to those of plants opened or closed allows the relative importance of the merger process to be assessed.

Each characteristic was calculated for each entry category using 1979 data and for each exit category using 1970 data. They were measured using weighted averages at the industry level.[49] In order to provide a reference point, the average characteristics of each turnover category were calculated relative to the same characteristics for continuing plants in the same 4-digit industry that did not change ownership between 1970 and 1979.

The ratios for each industry were then summarized for all manufacturing industries. The first summary measure to be calculated was the unweighted mean of the ratios for all industries; the second was calculated by summing across all industries to provide the weighted average characteristic of a category. Thus, average size of greenfield entries was calculated as the sum of the shipments of all such plants in all industries divided by the number of all such plants in all industries. Both the unweighted and weighted measures provide a similar picture of the amount of change taking place.[50] The weighted measures are emphasized in this section because they capture the total effect of a category rather than its average effect.

THE IMPACT OF FIRM TURNOVER

TABLES 10 AND 11 CAPTURE A NUMBER of weighted relative characteristics for three entry and exit categories for high-technology and other industries, respectively. On the entry side, the categories are: plant openings associated with entering firms (greenfield entrants), plant openings by continuing firms, and plants that were acquired by entering firms (acquisition entries). On the exit side, the categories are: plant closures made by exiting firms (closedown exits), plant closures by continuing firms, and plants that were divested by exiting firms (divestiture exits).[51]

Turnover resulting from the opening and closing of plants affects a different part of the firm size distribution than does turnover associated with changes in ownership. Plants built by greenfield entries tend to be smaller than average, are more specialized and are owned by firms that span fewer industries.[52] The plant openings of continuing firms tend to be more representative of the continuing sector. The plants acquired by entering firms are generally larger than average, more specialized and are acquired by firms that are diversified across more industries.

TABLE 10

THE CHARACTERISTICS OF ENTRANTS AND EXITS, HIGH-TECHNOLOGY INDUSTRIES[1] RELATIVE TO NON-MERGED CONTINUING PLANT IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979

	CHARACTERISTIC[2]			
		ANNUAL AVERAGE INCOME		
PLANT/FIRM CATEGORY[3]	LABOUR PRODUCTIVITY	PRODUCTION WORKERS	SALARIED WORKERS	WHITE-COLLAR JOBS AS A PROPORTION OF INDUSTRY EMPLOYMENT
	Ratio of characteristics for plant/firm category to non-merged continuing plants[4]			
Plant Openings				
Entering Firms	0.84	0.80	0.88	0.37
Plant Closings				
Exiting Firms	0.69	0.79	0.85	0.30
Plant Openings				
Continuing Firms	1.06	1.00	1.02	0.93
Plant Closings				
Continuing Firms	0.58	0.93	0.97	0.95
Plant Acquisitions				
Entering Firms	0.98	0.91	0.90	0.84
Plant Divestitures				
Exiting Firms	0.62	0.97	0.94	1.03

1. High-technology industries are shown in Table 1.
2. All of these characteristics are defined in the notes to Table 3. The productivity measure is value added per worker.
3. The plant/firm categories are defined in the notes to Table 5.
4. Each ratio presented in the table is the weighted industry average across the set of industries. For example, productivity was defined as the total value added divided by total number of employees.

SOURCE: Special Tabulations, Business and Labour Market Analysis, Statistics Canada

In order to evaluate the effect of plant entry and exit, the direction of the replacement process must be ascertained.[53] Since the primary tendencies are for (1) greenfield entrants to replace closedown exits and (2) plant openings by continuing firms to replace plant closures by continuing firms, it is the difference in the relative characteristic (i.e., productivity) within each of these matched pairings that is compared here.

The replacement of old plants by new plants has a productivity-enhancing effect in both high-technology and other industries. Within each set of pairings and for both high-technology and other industries, new plants were relatively more productive than closed plants. For example, Table 10 shows

TABLE 11

THE CHARACTERISTICS OF ENTRANTS AND EXITS, OTHER INDUSTRIES, RELATIVE TO NON-MERGED CONTINUING PLANT IN THE CANADIAN MANUFACTURING SECTOR FROM 1970 TO 1979[1]

PLANT/FIRM CATEGORY	CHARACTERISTIC			
		ANNUAL AVERAGE INCOME		
	LABOUR PRODUCTIVITY	PRODUCTION WORKERS	SALARIED WORKERS	WHITE-COLLAR JOBS AS A PROPORTION OF INDUSTRY EMPLOYMENT
	Ratio of characteristics for plant/firm category to non-merged continuing plants			
Plant Openings				
Entering Firms	0.85	0.86	0.94	0.44
Plant Closings				
Exiting Firms	0.68	0.81	0.89	0.43
Plant Openings				
Continuing Firms	1.11	0.98	0.97	0.83
Plant Closings				
Continuing Firms	0.83	0.93	0.91	0.95
Plant Acquisitions				
Entering Firms	0.95	0.98	0.95	1.30
Plant Divestitures				
Exiting Firms	0.90	0.98	0.97	1.30

1. For definitions of characteristics, plant/firm categories and the ratio see notes to Table 10. The sample of other industries is defined in Table 2.

SOURCE: Special Tabulations, Business and Labour Market Analysis Group, Statistics Canada

that the relative productivity of greenfield entrants in 1979 in high-technology industries was 84 percent of the continuing sector, but that of closedown exits was only 69 percent of the continuing sector in 1970 — for a gain of 15 percentage points over the decade relative to the continuing sector.[54]

In other industries, the net impact of replacing plants that closed with new plants was to increase the incomes of production workers. Closed plants paid relatively lower incomes to production workers in 1970 than did new plants in 1979. The same can be shown for the incomes of salaried workers. In high-technology industries a similar pattern occurred, except that the rise in the level of income for production workers was less in the case of firm closedowns and greenfield entrants. Increases in relative productivity occasioned by plant openings and closings were, therefore, accompanied by increases in worker income.

One of the marked differences between high-technology and other industries can be seen in the effect of entry and exit on the employment of white-collar workers. For greenfield entries and closedown exits in high-technology industries, the share of employment of white-collar workers increases, with virtually no effect in other industries. In contrast, for plant openings and closings by continuing firms, there is a slight decline in high-technology industries, but there is a substantial decline in the case of other manufacturing industries.

While there are similarities in the changes in productivity and income between high-technology and other industries occasioned by plant openings and closings, this is not the case for acquisition and divestiture. In other industries, there was little long-term gain from a merger. Relative productivity increased only marginally. The remuneration of production workers was unchanged; that of salaried workers fell slightly. The proportion of non-production workers remained constant. In contrast, relative productivity increased substantially in high-technology industries. There is also some indication that mergers in high-technology industries serve to restrain costs. Average remuneration of both production and non-production workers fell. In addition, the percentage of industry employment accounted for by non-production workers declined.

It has been postulated that high-technology industries offer fertile opportunities for foreign investment because these industries tend to utilize special assets that are not easily transferred, except through direct investment. However, not all such investments are or need be of the greenfield variety. Indeed, where plant scale is large and concentration is high, the preferred entry route is often via acquisition of existing facilities. The corollary for such industries, therefore, is that acquisitions in the form of mergers are undertaken here in order to transfer special technological assets fundamental to the production process and that, on average, mergers should be more successful than elsewhere. Our results confirm this hypothesis.[55]

NATIONALITY AND THE IMPACT OF PLANT OPENING AND CLOSING

IN ORDER TO ASSESS THE EXTENT to which the nationality of a firm affected the gains associated with plant openings and closings, plant births and deaths were divided into domestically and foreign-owned segments. The methodology of the preceding section was used to evaluate increases in productivity due to births and deaths within each segment.

Domestic greenfield entrants were 70 percent as productive as continuing plants in 1979, but domestic closedown exits were 62 percent as productive as continuing plants in 1970. The relative productivity of plant openings by continuing domestic firms was 87 percent, plant closings, 68 percent. The gain in each of these domestic categories was, therefore, substantial. The productivity of foreign greenfield entrants as of 1979 was 85 percent of continuing plants that did not merge;[56] foreign closedowns were 82 percent as productive as continuing plants in 1970. The relative productivity of plant openings by continuing foreign firms was 129 percent, plant closings, 87 percent. Thus, the gain in productivity from foreign plant turnover was only substantial for the plant creation and destruction process in foreign continuing firms. Foreign greenfield entry and closedown exit in high-technology industries once more show quite different patterns from all other categories — probably because exits were greater than entrants.

The same exercise was conducted for other industries with similar results; the replacement process in both the foreign and domestic sectors generally led to improvements in productivity. There was one exception, however, in that the foreign greenfield entry and closedown exit led to a substantial increase in productivity for other industries, but had little impact on high-technology industries. This is consistent with the results summarized in Table 9, which show that between 1970 and 1979 foreign firms were losing market share in high-technology industries with closedown exits exceeding greenfield entrants. During the same period the reverse occurred for domestic firms in the same categories. The failure of the turnover process to replace exiting foreign firms with new foreign entrants in high-technology industries meant that entry and exit contributed less to productivity growth in this sector than elsewhere.

NATIONALITY AND THE IMPACT OF OWNERSHIP CHANGES ON HIGH-TECHNOLOGY INDUSTRIES

HIGH-TECHNOLOGY INDUSTRIES attract more foreign than domestic firms — and the acquisition process reflects this. A higher proportion of acquisitions and divestitures involve foreign rather than domestic firms. Also, mergers in this sector seem to do relatively better than elsewhere. The relevant question for policy makers, then, must be: do those firms that are acquired by foreign investors exhibit superior performance?

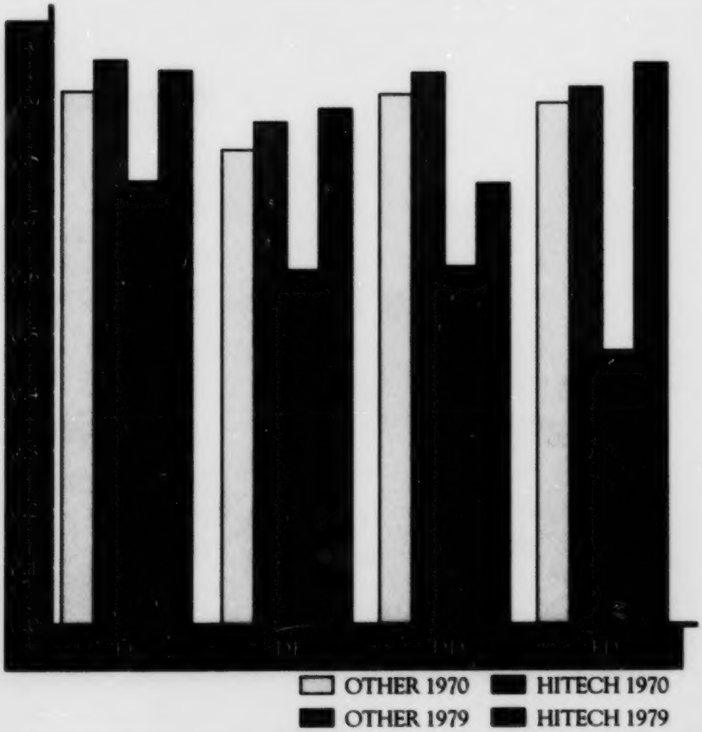
The impact of nationality on the success of acquisitions and divestitures was examined by dividing divestitures into four categories — specifically:

FF = a foreign-owned firm is acquired by another foreign-owned firm
DF = a domestically owned firm is acquired by a foreign-owned firm
DD = a domestically owned firm is acquired by another domestically owned firm
FD = a foreign-owned firm is acquired by a domestically owned firm

The labour productivity of plants in each acquisition/divestiture category is again expressed relative to the labour productivity of all non-merged continuing plants. This was done separately for high-technology and other industries. The relative productivity ratios were estimated for 1970, prior to the merger, and for 1979, after the merger. The results are shown in Figure 1.

FIGURE 1

RELATIVE PRODUCTIVITY OF ACQUISITIONS AND DIVESTITURES FOR HIGH-TECHNOLOGY AND OTHER INDUSTRIES: 1970 TO 1979



Note: The merger categories break down the divestor and the acquirer into domestic (D) or foreign (F)

The acquisition and divestiture process in other manufacturing industries had very little impact on the productivity of plants that changed ownership, irrespective of the nationality of the buyer and seller. Productivity increased only slightly in all cases relative to non-merged continuing plant. In contrast, the productivity of merged plant in high-technology industries increased substantially in all categories. Figure 1 shows that the weighted average relative productivity of merged plant in high-technology industries in 1970 was generally below unity; by 1979 it was closer to unity.

The high-technology sector is, therefore, distinguished by high productivity gains associated with the merger process which are in marked contrast to those found in other industries. Moreover, they are not confined to firms of just one nationality.

CONCLUSION

TWO ISSUES MUST BE ADDRESSED in any evaluation of government policy. What are the arguments for government intervention? What is the policy instrument that can best accomplish the stated objectives?

One of the most common arguments for the Canadian government to choose an interventionist policy focussing on foreign investment in high-technology industries is that high-technology industries may offer particularly good growth prospects or jobs with more desirable characteristics than other industries and foreign investment may detract from the potential offered by these industries. This does not appear to be the case.

This paper demonstrates that while Canadian high-technology industries have a higher proportion of higher paid white-collar jobs, they have neither particularly high growth rates nor very high paying jobs. But on balance foreign firms have been exiting the industry and, therefore, the performance of this sector may have suffered from the decline in the relative importance of foreign firms. The disappearance of foreign firms would have reduced growth rates in this sector; it would also have reduced the number of jobs in the higher paying white-collar class since a greater proportion of the workforce of foreign firms is made up of the white-collar group. The data then suggest that the problem lies not so much in too much foreign investment, but too little.

The paper also asks whether regulation and intervention in the high-technology sector can be justified by the existence of a particularly large productivity disadvantage faced by Canadian firms relative to foreign firms in high-technology industries than elsewhere. We showed that in these industries, Canadian firms did not perform as well as foreign firms, but the disadvantage they suffered was less than in other industries.

A third argument for intervention is that problems with competition are particularly great in high-technology industries because of high levels of concentration and foreign ownership and that regulation of mergers is therefore more important in high-technology industries than in other sectors. To investigate this argument, statistics on the amount of firm turnover due to entry, exit, growth and decline were compared for high-technology and other industries. Firm turnover data better reflect the amount of competition than do concentration statistics. We found that firm turnover in high-technology industries does not differ in any meaningful fashion from turnover in other industries. Special attention for the high-technology sector, therefore, cannot be justified on the basis that competition is a particular problem in this sector.

If it is difficult to find good reasons for focussing an interventionist strategy on high-technology industries, it is also difficult to justify the instrument chosen for regulation — the approval of foreign acquisitions. This instrument is appropriate if it focusses on a process that is particularly important, either because it is the primary route through which foreign firms gain market share or because it serves to redress a specific problem.

At present, foreign investment is regulated via the approval of foreign takeovers. Takeovers are only one of the means by which entry occurs and which cause market share to change hands between the domestic and foreign sectors. In order to evaluate the relative effectiveness of the regulatory instrument, we examined the extent to which the process being regulated was important relative to other forces which shift market share from the domestic to the foreign sector.

Changes in the importance of foreign firms were found to be primarily the result of greenfield entry and exit and of transfers of market shares from continuing firms in decline to continuing firms that were growing. Since neither of these aspects of turnover is amenable to direct control by a review agency that focusses only on mergers, the present policy can affect only a small portion of the changes occurring in the relative importance of domestic and foreign firms.

Finally, we focussed on the effects of foreign mergers so as to evaluate the extent to which there is evidence of a particular problem with the merger process in high-technology industries that regulation might redress. Since some have suggested that mergers simply churn resources as ownership is transferred from one group to another without much real impact, one reason for a regulatory process may be to reduce the costs associated with a process that has few benefits. We therefore evaluated the extent to which foreign takeovers have a positive effect on productivity. Takeovers by foreign firms were found to increase productivity in high-technology industries; so too did takeovers by domestic firms. We concluded that there was a genuine risk that regulatory policy affecting the market for corporate control — both domestic and foreign — may interfere with processes that have substantial benefits to the high-technology sector.

Our conclusions are straightforward. Policy should focus on stimulation and attraction, not just on intervention and control. Growth in the Canadian high-technology sector may not be as high as in other OECD countries because foreign firms have not been opening new plants at the same rate that they are closing them. This is not a problem easily solved by the regulation of mergers. Moreover, the mergers that were examined resulted in real productivity gains. A regulatory policy that has detrimental effects on the market for corporate control will be costly to Canada. All of this suggests that the primary role for Investment Canada should be to encourage foreign investment in Canada, not to discourage it.

ENDNOTES

1. For a discussion of the relationship between technology, R&D, growth and productivity, see Canada, Royal Commission on the Economic Union and Development Prospects for Canada (1985, Volume II, pp. 73-107), Economic Council of Canada (1983), and Palda (1984).
2. See the discussion in Science Council of Canada (1981, Table 1.1, p.18).
3. This is discussed further in Economic Council of Canada (1988).
4. For a discussion of these instruments, see Economic Council of Canada (1983, pp. 63-77), Mansfield (1985, pp. 93-94), and Palda (1984, pp. 89-100).
5. For a discussion of the motivation underlying foreign direct investment, see Caves (1982, pp.3-15) and the paper by Cantwell in this volume.
6. Canada, Royal Commission on the Economic Union and Development Prospects for Canada (1985, Volume II, pp. 92-94) and Mansfield (1985, pp. 84-89).
7. See Britton and Gilmour (1978), Canada (1972), Canada, Royal Commission on Corporate Concentration (1978, Chapter 8, pp. 181-209), Economic Council of Canada (1983), Levitt (1970), Palda (1984), and Task Force on the Structure of Canadian Industry (1968, p. 20).
8. See Canada (1972).
9. See Canada (1972, pp. 458-469).
10. A more recent concern is that Canada does not have a sufficiently strong base of indigenous multinational firms in knowledge-based industries. Screening inward foreign direct investment could provide a way to protect those Canadian-owned firms already in this category from falling into foreign hands. For details, see Ontario, Premier's Council (1988).
11. Science Council of Canada (1980).
12. Mazenkowski, *The Globe and Mail*, June 21, 1991.
13. For a discussion, see OECD (1986, pp. 58-76), and Canada, Ministry of Science and Technology (1978, p. 15).
14. Another approach is to define a high-technology industry in terms of its technological output, that is, in terms of such things as patents and major innovations. Unfortunately, the number of patents filed does not capture *all* technological outputs. There is also the problem of identifying and measuring major innovations. In light of these difficulties, this approach offers little advantage over the "use or intensity of R&D approach".
15. For further discussion see Palda and Pazderka (1982).
16. An example of this can be found in the federal government's willingness to trade off an increase in the R&D-to-sales ratio in the pharmaceutical industry in return for legislation raising the patent protection for drugs. For details, see Canada, Patent Medicine Prices Review Board (1989).
17. For example, OECD (1986, 59) uses R&D expenditures to production, while Canada, Ministry of Science and Technology (1978, 15) uses a combination

of two indicators of R&D intensity: R&D expenditures to value added and R&D personnel to total employment.

18. See OECD (1987) and, for published Canadian statistics, Statistics Canada (1984). Although, for this paper, we had access to unpublished R&D ratios at a more disaggregated level than is normally available, they were not available down to the 4-digit SIC level — the level of classification at which the merger and acquisition data were collected.
19. The OECD (1986, pp. 58-61) tried to resolve this problem by employing factor analysis to group industries into high-, medium- and low-technology industries.
20. One way of avoiding this difficulty is to concentrate on high-technology products rather than industries. Such products are defined as those which embody significant amounts of leading edge technology. The difficulty with this approach is that process innovations are excluded; moreover, selecting high-technology products involves a certain amount of judgement. Nevertheless, much attention has been paid to high-technology products, usually in connection with trade concerns. See Abbott et al (1989), Cardiff (1983), Lodh (1989), Magun and Rao (1989), and Statistics Canada (1989, 97-117; and 1985).
21. This is particularly likely to occur because R&D statistics are collected on a company basis. In contrast, employment and output data are collected at the level of the establishment. If a company changes the industry to which it is located, but all of its research activity is confined to its previous primary industry, then this may cause a change in the set of high-technology industries — even though no change has occurred in the location or application of research. See Statistics Canada (1984, 9-10) for further discussion of classification procedures.
22. The reference countries were Japan, Germany, France, the United Kingdom, Italy, Australia, Netherlands, Sweden, Belgium, Canada and the United States.
23. These are not the most R&D-intensive industries in Canada. These ten industries accounted for five of the leading Canadian manufacturing industries ranked by R&D-to-sales ratio. When a more inclusive measure of R&D intensity is used (the sum of the two ratios listed under R&D characteristics in Table 2), these ten industries account for eight of the leading ten.
24. See, for example, Task Force on the Structure of Canadian Industry (1968).
25. This test presumes each sample comes from a distribution with a different variance. An alternate test would be to treat the high-technology industries as coming from a distribution having the same variance as that possessed by the entire other industry sample. With the standard errors of means reported in Table 2, a reader can construct the appropriate confidence intervals.
26. If "invisible" R&D from the foreign parent that is not paid for were also included, it is likely that the percentage difference would be even larger. See Palda (1984, pp. 81-83) for further discussion.

27. A similar result is recorded if an alternate measure of concentration is used — the proportion of output accounted for by the four leading producers.
28. Output is measured by industry shipments, which differs from sales by the of change in inventories. Shipments in 1970 were used as industry weightings.
29. Differences in production worker wage rates (calculated as total wages divided by hours paid) between high-technology and other industries were also compared. The average wage rates in these two industry groups were not significantly different in either 1970 or 1979.
30. The results concerning the similarity in income levels between high-technology and other industries were confirmed using two other sources. The monthly employment, earnings, and hours survey (SEPH) collects information on average weekly earnings of all employees, where earnings is defined as gross pay for the week before any deductions. For 1979, the survey covered firms with 20 or more employees. In addition, the 3-digit 1960, not the 4-digit 1970, SIC was used. This necessitated the combining of 3911, 3912, 3913 and 3914 into a single industry, thus reducing the number of high-technology industries to seven. The 1979 mean annual average weekly earnings of all employees, production and salaried, in the manufacturing sector was $311.19; in the high-technology industries, somewhat lower — $303.95. (For details of the survey, see Statistics Canada, *Employment Earnings and Hours*, Cat. No. 72-002, a monthly publication.) The second source was the Labour Market Activity Survey (LMAS), full details of which may be found in Statistics Canada (1988). This is a longitudinal survey of employees for 1986 and 1987. It collects information on wages and salaries before taxes and other deductions. It uses the 3-digit 1980, not the 4-digit 1970 SIC, thus necessitating reducing the number of high-technology industries to seven. (1980, SIC = 321, 336, 334, 335, 374, 391 and 337.) The mean hourly rate of production workers in 1986 in high-technology industries was $11.53, in other manufacturing industries, $11.26. The corresponding mean hourly rates for salaried employees were $15.40 and $13.39, respectively. The hourly rates were calculated as the mean across employees in the high-technology and other industry sectors, using a methodology that weights full and part-time employment to derive average hourly wage rates. The distinction between production and salaried employees follows that based on the blue/white-collar occupational distinction. (See Baldwin and Gorecki, 1990c, Table 2.13, 29, for details.)
31. For a discussion of rents and high-technology industries, see the paper in this volume by Harris.
32. These are the parent organizations of plants in an industry. The firm may or may not be classified to the industry in which the plant is located.
33. Of those differentials in the high-technology sector between foreign and domestic plants, only the degree of plant specialization remained significant after size differentials and industry effects were taken into account. Size differentials were captured by the rank of the firm that owned the plant.

34. Full details of the Census of Manufactures may be found in Statistics Canada (1979). Creation of the database used to measure turnover is outlined in Baldwin and Gorecki (1990a).
35. It should be noted that a firm is defined as all plants under common control in the same industry. Thus, if enterprise A acquires enterprise B, which has plants classified to several industries, then more than one acquisition would be recorded in the work reported here.
36. For a discussion of entry and exit that compares the short-run to the long-run, see Baldwin and Gorecki (1990b, pp. 33-49; 1990d). In that study, much more turnover is shown to occur in the short than the long run. The difference between the short and the long run in high-technology as opposed to other industries is not considered here.
37. The exception is the plant acquisition category.
38. A referee has argued that greenfield entry and closedown exit is inordinately low in high-technology industries relative to what might be predicted. High levels of R&D should be associated with dynamic industries which, when combined with a higher industry growth rate, should lead to more, not less, turnover in high-technology than other industries. There are several difficulties with this line of argument. First, high levels of formal R&D may be associated with a routinized technological regime which is likely to inhibit, not encourage, entry (Audretsch and Acs, 1990). Second, account of other industry characteristics would need to be taken to determine, in a rigorous fashion, whether turnover was high or low in high-technology industries compared to what might be predicted. For example, while it is true that industry growth is positively correlated with entry, this applies only to domestic-firm entry via plant opening; foreign-firm entry does not appear to be related to the growth rate of Canadian manufacturing industries (Baldwin and Gorecki, 1987). As shown in Table 6, foreign firms dominate the firm-turnover process in high-technology industries.
39. For this exercise, acquisitions by entering firms and divestitures by exiting firms were not counted as exits or entrants. They were reconstituted as ongoing entities by reassigning to them the enterprise code originally assigned in 1970, and the growth and decline therein was included in line 2 of Table 7.
40. It only approximates the turnover process because, in reality, the replacement process is considerably more complex. The share gained by incumbents is partially at the expense of exits and partially at the expense of incumbents that are in decline. See Baldwin and Gorecki (1991a).
41. See Baldwin and Gorecki (1987).
42. For this calculation, the entry and exit acquisitions are treated as greenfield entry and closedown exit (row 1), and their growth and decline are omitted from the incumbent growth and decline category of row 2.
43. See Baldwin and Gorecki (1990b, Table 3-3, p. 37) for an indication of the variation in firm turnover across manufacturing industries.

44. A different issue is whether turnover is any less in high-technology industries than elsewhere, when differences in those industry characteristics that are related to turnover are taken into account. This is not pursued here because the actual level and not the predicted level is of relevance when regulatory burden is being assessed.
45. See Caves (1989).
46. See Eckbo (1986).
47. Several important issues are ignored herein. For one thing, only the long-run effect of mergers and entrants is considered; no attempt is made to measure the short-run costs of turnover and compare them to the long-run gains. Productivity is measured as output per worker; it could also be measured using total factor productivity. Efficiency rather than productivity could be investigated. Finally, the division of gains between shareholders and labour could be more fully outlined. All of these considerations are beyond the scope of this study, but might well provide an agenda for future research.
48. Lichtenberg and Seigel (1987).
49. These characteristics were calculated by summing across all plants in a particular category in an industry. Thus, average productivity of entrants was calculated as total value added divided by total production and salary earners in a particular category of firm.
50. They did, however, give quite different summary ratios since characteristics of entrants vary across industries and the intensity of entry is related to these values. For example, the weighted average output per worker of divested plant in 1970 is less than one, while the unweighted average is about one. This suggests that the least productive plants that were divested were also the largest. While this pattern may have some intrinsic interest, it is not pursued here.
51. In order to match plants in 1970 and 1979, all acquisitions and divestitures are compared. If only those plants that are divested by firms that exit an industry *and* are acquired by firms that enter an industry are used, the results are qualitatively the same.
52. Details of the specialization ratio and plant size are not provided in the tables.
53. See Baldwin and Gorecki (1991a) for a more detailed description of the process.
54. Unweighted averages show that the average productivity of greenfield entrants reaches that of continuing non-merged plants after about a decade. For more detail on the relative productivity of entrants in general, see Baldwin and Gorecki (1991b).
55. An alternate strategy was also used to define high-technology industries. The Canadian R&D/Sales levels of the OECD-designated high-technology industries were calculated and the lowest level was chosen as a floor. All Canadian industries that exceeded the floor were defined as high-technology industries. Many of the industries that were added to the OECD list of high-technology

industries as a result of this exercise fell into the medium high-technology group defined by the OECD. The extended set of industries had the same characteristic reported here — that mergers had a positive effect on productivity. This suggests that an extension of the definition of high-technology industries beyond that used here will not affect the conclusion that control changes contribute in an important fashion to productivity improvements.

56. Once again, these relative characteristics were taken by summing across all such plants in high-technology industries.

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DISCUSSANT'S COMMENT

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THIS PAPER EXAMINES the relationship among foreign ownership, plant turnover (particularly via acquisition and divestiture), and the structure and performance of high-technology industries. The basic conclusion is that the competitive process, as measured by turnover, is effective in replacing less productive firms with more productive firms and that this process generally works well in both high- and low-technology industries. However, in the high-tech sector, mergers are found to be a particularly important source of productivity gains, and this applies with almost equal force to both foreign and domestic firms. If true, the clear implication of this conclusion is that there is little role for the screening of foreign mergers in high-technology industries — or for that matter, in any industries. Indeed, the results suggest that there is only limited room for any form of industrial policy, since the competitive process works well.

Baldwin and Gorecki have assembled an impressive micro-industrial data base, and have provided important information on industrial mobility. That having been said, it must be noted that the time period covered in this study (1970-1979) encompasses neither the merger boom of the late 1960s nor that of the 1980s. It is therefore not clear whether any conclusions regarding mergers and acquisitions can be truly determined on the basis of such a short time period. Nevertheless, there is a great deal of information contained in this paper.

My remarks are limited to four general observations. The first refers to the relative performance of the high-tech industries, as summarized in Table 2. The results indicate that there are differences between high- and low-tech industries, but not as many as one might expect. In my reading of the table, the most important result is that the R&D/shipments ratio in the high-tech industries is below that required by the OECD for inclusion in the list. Therefore, the mean value of 2.7 percent is well below the 4 percent minimum which the OECD suggests is characteristic of high-tech industries in other countries. Relative to other OECD countries, Canada's R&D performance in high-tech industries is below average — as it is in other industries. Indeed, the Canadian high-tech industries do not do very well even in relation to other Canadian manufacturing industries, since only five (of ten) rank among the leading ten in terms of the R&D-to-sales ratio.

The authors suggest that in measuring Canada's performance, one should add to domestic R&D expenditures the payments made abroad for technology acquisition. When this is done, Canada's high-tech industries look considerably better relative to the OECD. However, unless the same type of expenditures are added to the OECD numbers, the comparison is not relevant. Even if one were to accept the idea of adding foreign payments for Canada alone, the large standard errors reported in Table 2 for both the R&D-to-sales ratio and the technology payments-to-sales ratio in the high-tech sector suggest that some Canadian industries still would not qualify as high-tech according to the OECD. It is probably worth adding that the patent data analyzed by Patel and Pavitt in this volume also indicate that large Canadian firms are not heavily engaged in inventive activity.

The under-performance of Canada's high-tech industries in terms of R&D may well explain some of the unexpected results in Table 2. It is found that growth rates in the high-tech industries are not uniformly high, and that these industries do not seem to be characterized by high income jobs. In addition, it appears that the export performance of these industries is not significantly different from other industries, and that imports exceed exports on average.

There is not much evidence of Canada being internationally competitive in the high-technology sector.

While it is not clear why Canada tends to under-perform in high- tech industries, one cannot rule out the possibility that the presence of foreign firms in these industries tends to crowd out domestic R&D. A recent study (Veugelers and Vanden Houte, 1990) suggests that in theory foreign competition may either encourage or discourage domestic R&D. However, the empirical evidence for Belgium indicated clearly that R&D undertaken by domestic (Belgian) firms was discouraged by the presence of foreign firms.

My second, and somewhat related point, has to do with the conclusion that "on the basis of the data, turnover is neither inordinately high nor low in high-technology industries". This statement is essentially correct if the standard of comparison is other Canadian industries. However, this is certainly not what one would expect in a sector characterized by technological dynamism. Indeed, there is now considerable empirical evidence which suggests that turnover (at least in terms of entries and exits) is typically higher than average in industries characterized by high rates of innovation and in environments conducive to entrepreneurial innovation. Thus, in a dynamic high-tech sector one might expect higher than average rates of turnover — a result which is not observed over this period. Again, there is some evidence suggesting that foreign ownership may be a causal factor. In a study with R.S. Khemani (1988) we found that domestic entrants were deterred by the presence of foreign firms, other things equal. Since the high-tech industries considered by Baldwin and Gorecki are among the most foreign-owned in Canada, it is possible that domestic entry has been inhibited.

These two points taken together indicate a high-tech sector which is not terribly dynamic, perhaps because its domestic component has not developed in the face of foreign competition.

The third point relates to the observation that foreign ownership declined over the period, and declined most in high-tech industries. Moreover, it appears from Table 9 that this decline occurred primarily as a consequence of the market share ceded by foreign firms closing plants. This result is interesting, suggesting as it might that foreign ownership tends to decline during periods when the relative level of merger intensity is low. Certainly, the recent increase in foreign ownership coincides with a period of intense merger activity. The implication is that the policy objectives of a foreign investment review agency may vary over time, ranging from concern over foreign investment during periods of merger booms, to concern over dis-investment at other times. However, we do need to know more about the process by which market share was transferred to Canadian firms over the 1970s. It is important to understand whether foreign-controlled firms closed plants because Canadian firms gained competitive advantage or because foreign firms were systematically restricting their rate of expansion. For example, it may well be the case that FIRA (and the climate which preceded it) caused foreign firms to close plants.

The final observations relate to the questions of mobility, transfer of market shares and productivity. The data suggest that the turnover process contributes to productivity growth through the replacement of less productive firms by more productive firms, and that this holds for all forms of turnover including acquisitions in the high-tech sector. It is difficult to evaluate this evidence. For one thing, the newness of such data make it difficult to determine whether the magnitudes involved are large or small. Certainly, all of us who have worked with similar data in Canada and in other countries have been impressed by how much turnover there is. The fact that approximately 40 percent of market share was transferred over the decade is obviously important, but we still do not know how important.

The productivity results are also interesting in this regard, since they do shed some light on the workings of the competitive process, and the degree to which firm turnover contributes to productivity growth. However, I have some reservations. The first is whether value-added per worker is a useful measure of productivity. This measure may well include elements of rents and it would be useful to know whether the results hold when other measures of productivity are employed. One might also question the decision to use weighted numbers which, in effect, treats each turnover category (entry, exit, etc.) as a single firm. While this procedure may be useful in measuring outcomes, it is achieved at the cost of understanding the process. In particular, it does not allow for statistical testing since there is no variation within each category. We therefore do not know whether productivity increases are significant; nor do we know whether the results are representative of most turnover.

The procedure by which all categories are measured in either 1970 or 1979, while perhaps dictated by the data, also calls for some caution in interpreting the results. This can be misleading because it does not track the performance of an individual plant. For example, a plant that entered in 1971 and exited in 1978 after a continuous decline in productivity will, if I understand correctly, not be recorded. Yet it will have tied up assets for nearly a decade. In general, the fact that many entrants will subsequently exit after periods of declining productivity is not captured.

Finally, the assumption that all replacement occurs within the same category (e.g. greenfield entrants replace closedown exits) may be reasonable when the categories are broad, but becomes questionable as they narrow, particularly with respect to ownership. It is not necessarily reasonable, thererfore, to assume that foreign closedown exits are replaced by foreign greenfield entrants, particularly in the high-tech industries where the former is large. It is possible that the turnover process, under different assumptions may be found, in some cases, to lower productivity.

In spite of these doubts I do not suggest that turnover does not positively affect productivity. Indeed, there is other evidence (Geroski, 1989) suggesting that entry does exactly that. But Geroski also found that only recent entry has a positive effect on total factor productivity and that its effect is not as great as that provided by innovative activity. Thus while turnover may affect productivity there may be other factors which affect it more. Given Canada's weak innovative performance, the positive effect of turnover may not be sufficient to maintain productivity at internationally competitive levels.

In the introduction, Baldwin and Gorecki quite reasonably suggest that intervention is warranted only when a "perceived problem can be shown to exist". My reading of the evidence suggests that a number of possible problems can be identified and that the turnover process may not be a sufficient competitive force to overcome these problems.

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8

Foreign Investment and Technological Development in Silicon Valley

INTRODUCTION

FEW TOPICS excite intellectual and political passions in the United States as much as inward foreign investment, particularly inward foreign investment in high-technology industries. In this paper, I take a cursory look at inward foreign investment over the last decade in Silicon Valley. I use "Silicon Valley" partly as a geographical representation — loosely as the San Francisco Bay Area, specifically the Santa Clara Valley and places nearby — and partly as a metaphor to represent high-technology industry in California, and the United States more generally. My data is sketchy and my conclusions are highly preliminary. Yet, the issues are of considerable interest to both managers and policy-makers in the United States and elsewhere.

FOREIGN DIRECT INVESTMENT IN CALIFORNIA

INVESTMENTS IN CALIFORNIA by persons outside the state have played a major role throughout the state's history, and include British financing of the railroads that opened California to the rest of the continent. However, foreign direct investment (FDI) — which is defined here as the establishment or purchase by citizens of another country of a significant ownership share and some management voice in a business enterprise or real property — is a relatively recent phenomenon that became prominent in the 1970s. While statistics showing the level and growth of FDI in California are outdated and of questionable reliability, other data show an increase from 31 transactions in 1976 to 244 in 1987 (Table 1). These include mergers and acquisitions; joint ventures and strategic alliances were also prominent (Table 2).

In addition to the traditional modes of direct foreign investment, the 1980s have witnessed a marked increase in indirect investment via venture capital funds. Eventually, when such a capital fund is dissolved — perhaps a

TABLE 1

NUMBER AND VALUE OF FOREIGN INVESTMENT TRANSACTIONS IN CALIFORNIA BY YEAR *1976 - 1986*

YEAR	NUMBER	NUMBER WHERE VALUE IS RECORDED	VALUE ($ MIL)
1976	31	17	$ 194.3
1977	27	19	638.8
1978	103	49	544.9
1979	134	64	4 850.1
1980	184	76	2 395.5
1981	149	49	4 197.1
1982	120	50	2 116.8
1983	114	56	2 318.0
1984	155	73	3 769.2
1985	147	66	6 173.6
1986	179	80	3 296.2
1987	244	NA	NA

SOURCE: California Department of Commerce, Office of Economic Research, Calculations from U.S. Department of Commerce, International Trade Administration (ITA), *Foreign Direct Investment in the United States: Completed Transactions, 1974-1983, Volume III: State Location*, June 1985; *1984 Transactions*, September 1985; *1985 Transactions*, September 1986, *1986 Transactions*, September 1987

TABLE 2

NUMBER AND VALUE OF FOREIGN INVESTMENT TRANSACTIONS IN CALIFORNIA BY TYPE OF INVESTMENT *1976 - 1986*

TYPE	NUMBER	NUMBER WHERE VALUE IS RECORDED	VALUE ($ MIL)	AVERAGE VALUE ($ MIL)
Total	1 343	599	$30 494.5	$50.9
Acquisition/Merger	382	208	16 286.4	78.3
Equity Increase	56	33	1 257.5	38.1
Joint Venture	54	13	712.2	39.6
New Plant	95	36	526.9	14.6
Plant Expansion	34	23	860.3	37.4
Real Estate	328	198	9 054.6	45.7
Other	326	58	950.8	16.4
Unknown	68	25	845.8	33.8

SOURCE: California Department of Commerce, Office of Economic Research, calculation from U.S. Department of Commerce, International Trade Administration (ITA), *Foreign Direct Investment in the United States: Completed Transactions, 1974-1983, Volume III: State Location*, June 1985; *1984 Transactions*, September 1985; *1985 Transactions*, September 1986; *1986 Transactions*, September 1987 decade or so after its domination — the equity investors obtain ownership shares in the portfolio companies that constituted the original venture fund. In the interim, the venture fund acts as a kind of intermediary between the foreign investor and the ultimate investee. Data from venture economics (Table 3) indicate that on average over $100 million a year was invested in such funds in California by foreign individuals or entities between 1980 and 1989. In relative terms, this is not a large amount, but it is large enough to indicate that foreign firms are now quite prepared to use venture capital funds as another vehicle for investing in California high-technology firms. As will be discussed later, traditional forms of venture capital are unlikely to be attractive in the future to investors desiring something other than a financial relationship with the companies in the venture fund's portfolio.[1]

Statistics showing country of origin indicate that since 1986 Japan has been the leading foreign investor in California. In 1987, Japan registered $8.1 billion of assets, shown at gross book value in property, plant and equipment (see Figure 1). Canada and the United Kingdom rated second and third respectively. Real estate recorded the largest share of gross book value of foreign investment (27.5 percent), followed by manufacturing. Investment in high technology constituted a significant and possibly growing proportion of total foreign direct investment.

It is by no means clear, however, that the economic moment of foreign direct investment can be summarized adequately by statistics on gross investment. A clearer picture of what is going on, and possibly what is at stake, can be gleaned from Table 3, which identifies specific investee and investor firms that have been involved in foreign direct investment in California from 1981 to 1990 in three industries: semiconductors, biotechnology, and computers. The circumstances surriunding five recent cases draw the far-reaching implications of these investments into sharp focus.

GENENTECH-LAROCHE

ON FEBRUARY 2, 1990, Hoffmann-LaRoche of Switzerland and Genentech of South San Francisco, signed an agreement enabling LaRoche to buy 60 percent of Genentech — the nation's largest, best capitalized, and most visible biotech firm. The transaction continues to attract great interest because of its potential impact on technological development in the biotechnology industry.

Genentech's motives appear to have been both financial and strategic. Genentech was concerned that further technological development and the worldwide commercialization of new biotechnology applications would require more cash and access to resources and capabilities it did not then have. LaRoche's cash infusion ($492 million) invigorated Genentech's R&D capability, enabling it to move projects that had been on hold into active development. Genentech will stay organizationally separate from LaRoche at least until 1995 — during which time LaRoche has agreed not to interfere in the management of Genentech operations. This appears to be reasonably assured by the fact that

TABLE 3

INVESTMENTS IN CALIFORNIA FUNDS

LIMITED PARTNER TYPE	NUMBER OF INVESTORS	NUMBER OF FUNDS	$ AMOUNT INVESTED
1980			
Foreign – Unknown Type	4	4	$18.5M
Foreign Financial Corp.	5	3	2.8M
Foreign Industrial Corp.	2	2	1.75M
Foreign Family/Individual	1	1	1.0M
Totals	12	7*	$24.05M
1981			
Foreign – Unknown Type	2	1	$1.65M
Foreign Financial Corp.	12	5	11.45M
Foreign Industrial Corp.	5	4	8.5M
Foreign Private Pension	1	1	1.0M
Foreign Family/Individual	8	3	8.95M
Totals	28	9*	$31.55M
1982			
Foreign – Unknown Type	2	1	$2.5M
Foreign Financial Corp.	8	7	8.9M
Foreign Industrial Corp.	4	3	4.65M
Foreign Family/Individual	6	4	10.9M
Totals	20	11*	$26.95M
1983			
Foreign – Unknown Type	8	8	$191.8M
Foreign Financial Corp.	15	9	17.2M
Foreign Industrial Corp.	3	3	2.8M
Foreign Private Pension	2	2	1.3M
Foreign Family/Individual	8	5	7.1M
Foreign Private Foundation	1	1	1.05M
Totals	37	17*	$221.25M
1984			
Foreign – Unknown Type	4	4	$4.8M
Foreign Financial Corp.	30	14	47.6M
Foreign Industrial Corp.	12	8	17.15M
Foreign Private Pension	11	7	13.1M
Foreign Family/Individual	9	6	5.55M
Totals	66	18*	$88.2M
1985			
Foreign – Unknown Type	5	4	$10.6M
Foreign Financial Corp.	16	7	173.0M
Foreign Industrial Corp.	18	4	23.0M
Foreign Private Pension	6	3	16.5M
Foreign Family/Individual	3	3	4.8M
Totals	48	12*	$227.9M

TABLE 3 (continued)

LIMITED PARTNER TYPE	NUMBER OF INVESTORS	NUMBER OF FUNDS	$ AMOUNT INVESTED
1986			
Foreign – Unknown Type	2	2	$19.2M
Foreign Financial Corp.	18	6	18.4M
Foreign Industrial Corp.	16	7	13.6M
Foreign Private Pension	1	1	0.2M
Foreign Family/Individual	3	2	1.5M
Foreign Government	1	1	0.5M
Totals	41	12*	$53.4M
1987			
Foreign – Unknown Type	3	2	$64.5M
Foreign Financial Corp.	24	11	59.3M
Foreign Industrial Corp.	11	8	53.8M
Foreign Private Pension	8	5	18.75M
Foreign Public Pension	1	1	10.0M
Foreign Family/Individual	6	3	4.55M
Foreign Government	2	2	2.5M
Totals	55	15*	$213.4M
1988			
Foreign – Unknown Type	3	3	$6.75M
Foreign Financial Corp.	14	10	28.8M
Foreign Industrial Corp.	11	10	21.0M
Foreign Private Pension	2	2	12.0M
Foreign Public Pension	1	1	8.0M
Foreign Family/Individual	2	2	1.35M
Totals	33	17*	$77.9M
1989			
Foreign Financial Corp.	11	7	$34.5M
Foreign Industrial Corp.	12	5	21.5M
Foreign Private Pension	2	2	6.0M
Foreign Family/Individual	3	2	4.25M
Foreign Government	1	1	10.0M
Totals	29	12*	$76.25M

* Total without double counting.

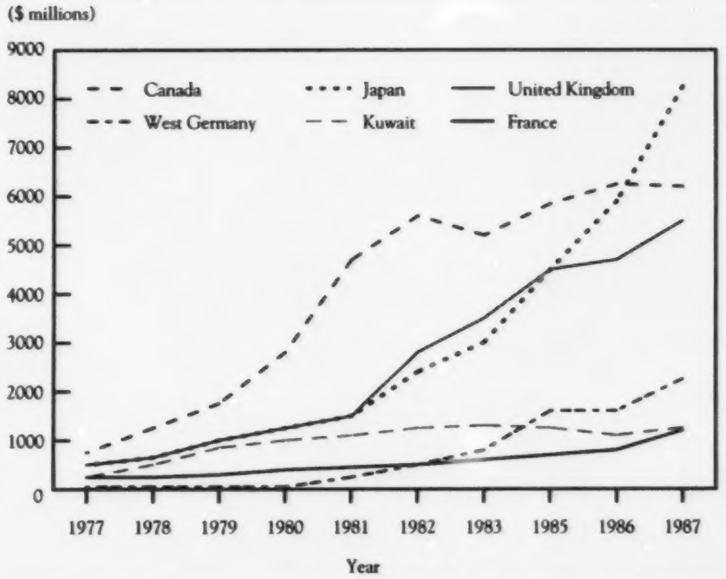
SOURCE: Private database, Venture Economics, Inc., Needham, MA, December 1990

during the period LaRoche will control only two of the 13 seats on Genentech's board.

With this investment, LaRoche has substantially strengthened its long-term technological position in biotechnology in the United States. While LaRoche already has laboratories in New Jersey, the company has not been successful in recombinant technology in the United States or elsewhere. There

FIGURE 1

AFFLILIATE BOOK VALUE OF PROPERTY, PLANT AND EQUIPMENT INVESTED IN CALIFORNIA BY COUNTRY 1977 – 1987



SOURCE: California Department of Commerce, Office of Economic Research, Fopreign Direct Investment in California, February 1990.

may be no significant short-run technological benefits for LaRoche as Genentech technology is not licensed to LaRoche under the agreement, and there is no technology "transparency" for five years. However, LaRoche has the right to buy the remainder of Genentech's stock at its fair market value in 1995. It will then have complete access to Genentech's product line — which means everything in the pipeline including Genentech's future research results.

This investment occurred partly as a reaction to the high risks and costs associated with using U.S. public markets to finance technological development in the biotechnology industry.[2] In 1988 Genentech's stock fell from 47-1/2 to 14-3/8 because of disappointing sales of TPA, its drug to facilitate recovery from heart attacks. (In August 1990, Cetus stock also fell 12 points due to a temporary set-back obtaining FDA approval for Interluken II, its anti-cancer drug, which has already been approved in Europe.) In part, LaRoche's purchase also supports the claim that Genentech and other American companies have the lead in the biotechnology industry, and by far the cheapest way for the Europeans and the

Japanese to narrow the gap is for them to acquire American biotech firms.[3] It also acknowledges the fact that stand-alone biotech companies like Genentech — without substantial downstream facilities in manufacturing and marketing — need to join forces with established firms to accomplish this end. Previously, strategic alliances were thought to be adequate; the Genentech experience suggests that further integration is required. It is also important to bear in mind, however, that Genentech was already profitable[4] and that it had considerable cash reserves. Some interpret the sale as evidence that Genentech's owners did not have the tenacity or patience to stick it out.[5] However, even if the owners were worried about the long-run viability of Genentech in the absence of a significant stream of internal cash flow, it is difficult to avoid the conclusion that U.S. equity markets are not the place to finance long gestation industries.

WYSE

ESTABLISHED IN 1981, Wyse Technology, a San Jose-based manufacturer of computer terminals, operated as an independent company until late 1989 when, following a period of financial distress, it was purchased by a Taiwanese consortium — Channel Intercorporation Corporation. The members of the consortium were the China Trust Co., the Executive Yuan Development fund (a Taiwan Government development fund), two petrochemical companies, and Mitac International Corporation, Taiwan's second largest computer company. The sale marked the first time a Taiwanese concern has purchased all the stock of an American company. Interestingly, two of the founders of Wyse, Grace and Bernie Tse, were themselves American-educated Taiwanese citizens, residing in the United States.

By 1986, five-year old Wyse Technology had become the world's largest independent terminal supplier, second only to IBM in terminal volume. The San Jose-based company manufactured its terminals at a high volume, vertically integrated and automated factory in Taiwan. However, during the last half of 1980 sales fell by more than 50 percent. The company faced a collapsing computer market and an industry-wide shortage of memory chips as well as competitive new products. Wyse was locked into a high volume, vertically integrated strategy and seemed unable to adjust.[6] During the same period, the company lost a great deal of money because of its ill-timed diversification into PC clones.

Wyse responded to its problems by taking on debt and by cutting personnel in both the United States and Taiwan. Nonetheless, after recording losses of $7.6 million on (projected) sales of $231.4 million in 1990, Wyse agreed to sell for close to $270 million in cash.

For the buyers, the principle benefit in purchasing Wyse was the access obtained to the company's well-developed distribution channel in the United States.[7] Mitac particularly (having had little success selling its brand-name computers in the United States) expected to benefit directly by exploiting Wyse's relationship with Businessland Inc. Mitac hoped to channel its products onto crowded retail shelves and capture margin and control by moving downstream into the distribution network.[8] Wyse's well-established brand name and "goodwill" presented additional benefits for the investors.

The Taiwanese consortium will not be passive investors. The group plans to install Morris Chang as Wyse's new chairman. At present, Mr. Chang heads the government-sponsored Industrial Technology Research Institute (ITRI) in Taiwan.

FAIRCHILD/SCHLUMBERGER/FUJITSU

IN 1979 FAIRCHILD CAMERA AND INSTRUMENT, one of the world's first semiconductor producers, was bought by Schlumberger, a French oil services company, for $425 million. Despite Fairchild's[9] fading product line and the 1982-83 semiconductor slump, Schlumberger tried to implement a radically new business strategy almost overnight. Under Schlumberger direction, Fairchild decentralized its corporate structure, laid off half of its workforce, and refocussed on semiconductors. Schlumberger also poured cash into R&D and new plant and equipment.

But the strategy failed. By 1984, Fairchild was eclipsed by its four major spinoffs — Signetics, Advanced Micro Devices, National Semiconductor and Intel. In the face of mounting losses, Schlumberger shut down Fairchild's optoelectronics division in February 1983. In March, it disbanded Fairchild's MOS operation. By mid-1983 Fairchild's presence in EPROMs, SRAMs, and DRAMs had virtually disappeared. At about this time Fairchild also stopped manufacturing its custom hybrid circuit modules and began phasing out a test and assembly plant in Indonesia. This massive retreat was accompanied by an equally massive exodus of experienced managers. Thomas Roberts, a Schlumberger manager who was installed as president and CEO at Fairchild, was severely criticized, as was Schlumberger's decision to appoint other top managers who had no semiconductor experience. In 1983 Schlumberger sought out semiconductor expertise, and hired Donald Brooks, a Texas Instruments senior vice president — but the losses continued. In October 1986 Schlumberger agreed to sell 80 percent of its position in Fairchild to Fujitsu.

The (proposed) deal with Fujitsu purported to have several short- and long-run benefits for both companies. In the short run, Fairchild would benefit because Fujitsu would provide capital resources to shore up Fairchild finances. In return, Fujitsu would gain the onshore production capabilities it was seeking. Fujitsu would also gain access to Fairchild's first-tier distribution network. This consideration was very important, since some distributors (including Wyse Labs discussed earlier) refused to "handle any product with a Japanese brand name".[10] Wilfred Corrigan, chairman of CSI Logic, referred to the proposed investment as "a backdoor way to buy into U.S. manufacturing" as well as a "backdoor to distribution channels".

Over the long-term, Fujitsu promised to be a source of patient capital with a commitment to R&D. It was also hoped that Fujitsu might share its advanced optoelectronics technology. There were other potential technological complementarities as well. Fujitsu's MOS capabilities could replace those lost by Fairchild in 1983, and were seen to be important in the development of a new generation of bipolar circuits. Although Fairchild may have had some technological advantage over competitors with respect to this class of circuits, it was by no means the only producer. In a larger context, the development of custom chips brought systems producers and chip manufacturers much closer together. Many industry managers and analysts cited the high degree of vertical integration in Japanese firms as a reason for their relative success. It was Brooks' view that the co-development of system hardware and software with semiconductor technology was the logical extension of the expanding role of the customer in the innovation process.[11]

Specifically, it appears that one element of the plan was to merge Fairchild's capabilities in bipolar gate arrays with Fujitsu's capabilities in supercomputing so as to boost supercomputers' power, and even build new "minisupers". In combination, these would put supercomputer power in the hands of conventional mainframe customers and catapult the two firms into the next era of computing. It was here, however, that the deal got into trouble.

The Pentagon voiced its concern — that one group of bipolar circuits manufactured by Fairchild, using emitter-coupler logic (ECL), was particularly crucial to the operation of computers embedded in certain advanced weapons. Defense Secretary Weinberger argued to the Administration that the merger would make the Defense department dependent on a foreign source for a key technology. This is a questionable argument, since no similar concern was raised when the French company Schlumberger bought Fairchild. But concerns were also expressed by certain personnel at Cray Research, the major American producer and supplier of supercomputers to the Pentagon, which gave support to Weinberger's position. Apparently, sources at Cray and at ETA Systems complained that they had had trouble getting shipments of certain Japanese integrated circuits. Lloyd Thorndike, president of ETA Systems, claimed that "Japanese firms with supercomputer lines were withholding new high-speed IC's from U.S. firms".[12] Potential leakage of Cray supercomputer designs to Fujitsu was also a point of concern.

Commerce Secretary Malcolm Baldridge urged the Administration to block the transaction. He criticized the protection by the Japanese of their home supercomputer industry and saw the merger as a threat to the competitiveness of the American industry. The mounting political furor caused Fujitsu to back away from the deal. But the story does not end there. Fairchild pursued ties with Fujitsu anyway, and eventually Fujitsu was persuaded to join a management group in a buyout attempt. However, the group was outbid by National Semiconductor, which bought Fairchild for $122 million in stock and warrants — approximately 25 percent of the purchase price paid by Schlumberger seven years earlier.

National Semiconductor's acquisition of Fairchild created a $2 billion to $4 billion company. Industry executives praised the deal, saying it would help National and the American industry compete worldwide but the acquisition also marked the end of an epoch — with an industry pioneer being acquired by one of its own former spinouts. It appears, too, that emotions, not national technological issues, carried the day. Fairchild was made out to be a technological leader in the industry and a unique American supplier of a key technology. Neither of these appears to have been true. Rather than dealing with the fundamental problems of the Schelenberger/Fujitsu deal, the government moved to block the transaction, amidst considerable confusion about the intentions of all parties.[13] It is probably true that Fujitsu would have enhanced Fairchild's technological position. Yet Fairchild, and its potential sale to Fujitsu, became a symbol of Silicon Valley's proud heritage and declining American competitiveness, and the deal came unstuck.

AKHASIC MEMORIES AND MIPS

I NOW CONSIDER the cases of two high-tech companies — Akhasic Memories and MIPS — both of which were acquired by the same Japanese company, Kubota Ltd. Kubota is a 100-year-old manufacturer of heavy machinery, perhaps best known for its line of farm equipment, with sales in the range of $5.5 billion. For some years now, it has been a major foreign investor in American high-tech companies. As of July 1990, its investments in the United States were approximately $200 million. In California, these investments include equity stakes in Stardent Computer, C-Cube Microsystems, MIPS Computer, Rasna Computer and Maxoptix. Investments outside California include ownership of Domain Technology, purchased for $66 million, and a $6 million, 9.2 percent stake in Exabyte of Boulder, Colorado.

Akhasic Memories

Although founded only in 1982, Akhasic was already in trouble by 1986. It had run out of cash and was two-and-a-half years late to market with its thin-film memory disk. Meanwhile, Komag, its closest competitor, had marketed its version of the disk a year earlier, gone public, and raised $135 million.

In Japan, Kubota had just built a disk production plant in Osaka, but was having difficulty exporting its products to the American market — which represented 90 percent of the world memory disk market. Kubota believed its problems were attributable to a technology gap, which would take three years to close, and the strong yen. Acquiring Akhasic Memories, therefore, would solve the first problem and turn the second on its head — it would boost Kubota's access to new technology and take advantage of the strong yen — which made the acquisition look cheap.

The timing was good for Akhasic as well. Despite revenues of $3.5 million by 1986, venture capital funds had become "very jaded toward the disk drive business and anything associated with it".[14] Akhasic needed at least $10 million to bring its production up to profitable levels. Akhasic and Kubota settled on a

$20 million buyout price. Kubota immediately sent a team of 10 technicians to Akhasic, who spent two weeks studying the technology.

MIPS Computer

MIPS is primarily a designer of reduced instruction-set computing (RISC) microprocessors and systems and related software and components. Founded in 1985, it became one of the fastest growing hardware firms in Silicon Valley reaching $40 million in revenues by its third year. In its early years MIPS promoted the RISC idea very aggressively to potential buyers such as Digital Equipment Corporation (DEC), Stardent (then Ardent), and Tandem Computers. Early buyers and venture capitalists were convinced of its worth and many remained so. By mid-1987, the latter had invested $37 million. In 1988 DEC bought a five percent equity stake.

In October 1987 Kubota offered to buy MIPS for $25 million, just when MIPS was at a breakeven point in its financing. Kubota agreed to a base valuation of $120 million for MIPS — which was unheard of at the time for a company at MIPS' level of development. A purely financial motivation for the offer by Kubota appears unlikely. Paradoxically, financial motivation by MIPS seems more likely because the company needed cash to pursue its business objectives. The Kubota money solidified MIPS' position in the market.

Kabota's investment in MIPS was not a rescue effort (as was the case with Akhasic Memories). Kubota appears to have wanted access to a technology with high potential as well as a "listening post" to aid their commercial intelligence in the United States market. Moreover, the RISC technology was crucial for Kubota's long-term strategy — to be a presence in the workstation and supercomputer markets.

Discussion

Kubota's corporate strategy, with respect to these and other deals, is generally seen to be long-term. It appears to be two-sided. On the one, Kubota is motivated to develop or acquire new computer technologies that will transform its traditional businesses in machinery and mechanical automation. On the other side, Kubota is motivated to diversify and is attracted to the workstation and supercomputer markets because of their growth prospects.

Kubota's investments in Stardent (Ardent, before its merger with Stellar Computer), Rasna, and MIPS all serve to illustrate these double motives. Its association with Stardent, a graphics supercomputer firm, provides Kubota with access to Stardent's technology and also allows Kubota to manufacture Stardent's sophisticated Titan mini-supercomputer in a new $200 million factory in Yamagashi, Japan. These computers use components from MIPS, another Kubota-owned company. Rasna, a software firm, is well-known for its work on programs for computer-aided design with mechanical engineering and machinery-design applications. Computer tools for fluid modelling in refinery development are one set of applications of particular interest. To achieve their goals in a world of converging technologies, Kubota appears to be investing in all the key areas: microelectronics, hardware and software. By following this strategy, Kubota clearly expects to compete more effectively in the various markets in which it already operates and also enter new, rapidly developing markets. There is little doubt that some significant American technology is being transferred to Kubota, and that the net flow is outward, although that direction may change in the future.

The long-term implications of Kubota's investment plans cannot be ignored. Naohisa Matsuda, a vice president of Kubota, explains his company's actions with respect to technology transfer from Stardent by saying, "We are only manufacturing the machines. All the designs are done in the United States.".[15] He went on to say that it would take 20 years for Kubota to develop the design skills of Stardent and other major computer makers.

OBSERVATIONS ON FOREIGN DIRECT INVESTMENT IN CALIFORNIA

A PRINCIPAL REASON UNDERLYING direct investment in Silicon Valley manufacturing, from the foreign investor's perspective, is to gain access to the technology and distribution channels for high-technology products. Silicon Valley is perhaps the world's most prosaic and creative incubator of new technology-based firms, particularly in semiconductors, biotechnology, and computers. The region has an unmatched capacity to spawn new enterprises and sustain them through early technological development.

As development expenses rise and as cash constraints become critical, however, the financial infrastructure on which so many of these firms depend — venture capital and small amounts of bank debt collateralized by receivables or equipment — is inadequate or too expensive to fuel growth. Invariably, cash, provided by other companies with a keen interest in the technology and/or the distribution facilities of the investee is most likely to be the source of additional capital. Those firms with available capital and the willingness to commit it are generally foreign, and frequently Japanese.

The willingness of foreigners to invest is far too commonly attributed to the higher cost of capital in the United States.[16] This difference was never great and has now evaporated.

The different patterns of investment behavior are due mainly to differences in management approaches and corporate governance between American and foreign firms. Foreign firms such as Hoffmann-LaRoche and Schlumberger tend to be privately held or are large Japanese enterprises that are less beholden to their stockholder interests (in the short term, at least) than their American counterparts. There are also differences in industrial structure between the United States and Japan, with Japanese firms commonly embedded in *keiretsu* structures — which have ready access to bank capital and a low propensity to allocate earnings to dividends or stock buybacks. Many foreign firms, particularly the Japanese, willingly accept a longer time horizon that their American counterparts. The Kubota example illustrates this well. These considerations reflect significant differences in the financial structures between American and Japanese firms. They also point up the greater managerial concern of the Japanese with respect to building technological competences, rather than particular products.[17] With technological competence and capabilities at center stage, Japanese firms are free to focus on the long-term and to imagine constellations of future products deriving from their technological capabilities.

The growing importance of Japanese direct investment in California "manufacturing" is of great interest in the United States, if not elsewhere. Such investment takes a number of forms:

First, there is corporate investment — such as when a Japanese company takes a direct equity stake in an American venture. This form is illustrated by Kubota's investment in MIPS and Stardent. Unless such investments reach a threshold of 10 percent of outstanding issue, and are part of some underlying strategy, they are of little interest here.

A venture capital vehicle, such as a partnership is another major form of investment. Within such an arrangement, Japanese corporate investors, often in collaboration with other investors, provide monies in venture capital funds which in turn take equity positions in publicly-traded ventures. Kubota has actively used this technique in Silicon Valley. So has Mitsubishi. In practically all such instances, Japanese investors have considerably more than a financial interest in their investee. This is the case whether the Japanese direct investors or or the investee is simply one of several companies in the venture capitalist's portfolio. As discussed earlier, in many instances immediate financial returns are decidedly secondary. This, in part, explains the willingness of the Japanese to pay high prices for equity positions.

What the Japanese usually want with their investments in Silicon Valley — but do not always receive — is a window on new technologies and markets. Because the Japanese system does not have the entrepreneurial capacity of Silicon Valley,[18] it is extremely important for Japanese firms to find ways to gain access to new technology and to legitimize their internal efforts at developing new technology. Silicon Valley firms thus often help pilot Japanese enterprises and provide them with new early-stage technologies and windows on market evolution. This not only fuels innovation in Japan, it also legitimatizes new initiatives. Because failure is "costly" in Japan — individuals who lead a company down a blind alley often face high levels of ostracism, uncommon in California — the guiding light provided by Silicon Valley firms is often of considerable moment.

Frequently, venture-funded American firms find themselves unable to finish what they start. In such circumstances, Japanese corporate investors often

TABLE 4

SOME DIRECT FOREIGN INVESTMENT IN CALIFORNIA, 1981 - 1990

FIRM	CITY	INVESTOR	COUNTRY	AMOUNT OF INVESTMENT ($MILLIONS)	HOLDING (PERCENT)	YEAR
SEMICONDUCTORS AND EQUIPMENT						
Exel Microelectronics	Milpitas	Rohm Corp.	Japan	5.7	60.7	1986
US Semiconductor		Osaka Titanium	Japan		100	1986
NBK Corp.	Santa Clara	Kawasaki Steel	Japan	9.4	100	1985
T.A. Hand, Inc.		Showa Musen Kogyo Co.	Japan	.3	100	1981
Syncor Int'l	Chatsworth*	Govt. of France	France	24.2	100	1983
Telmos	Sunnyvale	Merlin Gerin SA	France	4.1	100	1985
Zymos	Sunnyvale	Daewoo Corp.	S. Korea	13.4	35	1986
Telmos' Production Facility	Sunnyvale	Rohm Co.	Japan	1.5	100	1987
Tera Micro Systems		ASCII Corp.	Japan		25	1990
Semi-Gas	San Jose	Nippon Sanso	Japan		100	1990
Aegis Inc.	Foster City	Asahi Glass/Olin	Japan		50	1987
Monsanto's Polysilicon Unit	Palo Alto	Huels	Germany		100	1989
Siltec	Menlo Park	Mitsubishi	Japan	32.0	33	1986
Panatech's Semicond. Div.	Palos Verdes*	Ricoh Co.	Japan	1.1	100	1987
Siscan Systems	Campbell	Mitsubishi	Japan		11.5	1985
GTI Corp.	San Diego*	individual	South Africa	6.0	100	1987
Varian's Tube Division	Palo Alto	Thorn EMI	UK		100	1983
Marumen Integ. Cir.		Toshiba	Japan		2.7	1980
Xicor	Milpitas	S.G. de l'Horlogerie	Switzerland		15	1983
(NEC)	Mountain View	NEC	Japan		100	1981
Diamon Images	Los Gatos	Kanematsu-Gosho	Japan		10	
Waferscale Integ.	Santa Clara	Sharp	Japan		3.5	
Benzing	San Jose	Kanematsu	Japan		7	1984
Micro Linear	Sunnyvale	Kyocera	Japan		ND	ND
Vitelic	San Jose	Sony	Japan		ND	ND
Exar	San Jose	Rohm	Japan		61	1985
Focus Semicond.	Sunnyvale	MIP Equity	Netherlands	5.0	100	1987
Integrated CMOS	San Jose	Toshiba	Japan	4.0	14	1989
Vitesse Semicond.	Camarillo*	Thomson	France		ND	1990
(Toshiba Semicond.)	Sunnyvale	Toshiba	Japan		100	1986
BIOTECHNOLOGY						
Cytel	La Jolla*	Sandoz	Switzerland	30.0	20	1989
Zoecon		Sandoz	Switzerland		100	1983
Intermedics Intraocular	San Diego*	Pharmacia AB	Sweden		100	1986
Immunetech	San Diego*	Tanabe Seiyaku	Japan			1988
Chiron	Emeryville	CIBA-Geigy	Switzerland		6.2	1989
Cetus	Emeryville	Roche Holdings	Switzerland		3.5	1989
Mycogen	San Diego*	Kubota	Japan		9.6	1987
Gen-Probe	San Diego*	Chugai Pharm.	Japan		100	1989
Genencor	S.San Francisco	Cultor Oy/Kodak	Finland/U.S.		100	1990
Codon		Schering AG	Germany		100	1990
Adv. Genetic Sci.	Oakland	AB Cardo	Italy		100	1986
Intl. Immunology		Nitto Boseki Co.	Japan		100	1986
Genentech	S.San Francisco	Roche Holdings	Switzerland		60	1990
COMPUTER HARDWARE/PERIPHERALS						
Dataproducts	Woodland Hills*	Hitachi Koki/ N. Sanso	Japan		100	1990
Silicon Graphics	Mountain View	NKK Corp.	Japan	5.0	35	1990
Akhasic Memories	Santa Clara	Kubota	Japan	15.0	100	1987
Komag	Milpitas	Asahi Glass	Japan	20.0	17	1986
Komag	Milpitas	Kobe Steel	Japan	20.0	20	1990
C-Cube Microsystems	Shingle Springs	Kubota	Japan		ND	ND

TABLE 4 *(continued)*

FIRM	CITY	INVESTOR	COUNTRY	AMOUNT OF INVESTMENT ($MILLIONS)	HOLDING (PERCENT)	YEAR
Lam Research	Santa Clara	Sumitomo Metal	Japan	5.0	5	
Maxoptix	San Jose	Kubota	Japan	12.0	12	
MIPS Computer	Mountain View	Kubota	Japan	15.0	25	1987
NeXT	Redwood City	Canon	Japan	100.0	17	1989
Poquet Computer	Sunnyvale	Fujitsu	Japan		38	ND
Ardent Computer	Sunnyvale	Kubota	Japan	26.0	44	1989
Counterpoint Computer	Sunnyvale	Acer	Taiwan		100	1986
Wyse	San Jose	investor group	Taiwan		100	1990
Atari Games	Milpitas	Namco	Japan			
Britton Lee	Los Gatos	Mitsubishi	Japan		ND	ND
David Systems	Sunnyvale	Pirelli	Italy	2.0	100	1985
LaPine	Milpitas	Kyocera	Japan	2.1	ND	1987
SyQuest	Fremont	JAFCC, Nippon Sys.	Japan		ND	ND
Tolerant (Eritas)	San Jose	Digital Ltd.	Japan		1	1986
Dana Computer	Sunnyvale	Kubota	Japan	20.0	100	1986
Momenta	Mountain View	group	Singapore		1990	
System Integrators		Birmingham	UK		100	1985
National Controls	Santa Rosa	Staveley Inc.	UK		100	1985
Apple's plant	Garden Grove*	Alps Electric	Japan		100	1985
Forward Technologies	San Jose	Digital Computer	Japan		100	1985
Victor Technologies	Scotts Valley	Datatronics AB	Sweden		100	1985
Datametrics	Chatsworth*	Oranje-Nassau	Netherlands	.8	100	1986
Fortune Systems	San Jose	Govt. of France	France		100	1986
Micro Five Corp.	Costa Mesa*	Samsung	S. Korea	.9	100	1986
Saber Labs	San Francisco	BMW	Germany			1986
Calay Sys.	Irvine*	Agiv	Germany		100	1987
Corporate Data Sciences	Manhattan Beach*	Telfos TLC	UK		100	1987
Calcomp's Systems Div.	Anaheim*	ISI-CAD	Germany		100	1987

* = Southern California location   ND = not disclosed

SOURCE: The data was compiled from the following sources: International Trade Administration (ITA), *Foreign Investment Transactions, 1980-1988,* various issues of *Japan Economic Institute Report, Business Week, Bio/Technology, San Francisco Chronicle,* and a conversation with a representative of the Semiconductor Industry Association. One hundred percent ownership represents an acquisition or merger as identified in the ITA data.
Since the ITA data rely heavily on business and trade publications sources, as opposed to more systematic surveys, the data here may not be representative of actual FDI activity in California.

provide what the American firms lack — patient capital, engineering talent, manufacturing excellence and access to the Japanese market. Clearly, there is a symbiotic relationship here which generally benefits both parties. But more importantly, the United States must recognize that such Japanese investment signifies the failure of American organizational structures and capital markets to provide large-scale investments to support uncertain new technologies.

It is important to recognize that it is not only existing Japanese competitors who are making strategic investments in high-tech Silicon Valley companies. Often, large low-tech businesses like tobacco and steel companies use such investments to underpin their diversification strategies. Such firms are not only cash rich; they have long-term strategic visions, many of which look ahead 99 years. An acquisition now is often seen as a way to preserve options into the future. Such American firms are usually delighted to include a high-tech Silicon Valley company as part of their investor group.

The success of an investment from the Japanese perspective — particularly if it occurs through venture funding — is likely to depend importantly on whether personal relationships develop between representatives from the Japanese investor and the Silicon Valley investee. Opportunities for technology transfer and market success depend on the continued flow of information and personnel. The employment of a traditional venture capitalist as an intermediary often serves to stifle information exchange and block all but occasional interaction among the principals. In this regard, it is likely that the traditional forms of venture capital — in which investor and investee are held at arm's length — will wane in relative importance over time as mechanisms to place Japanese investment in Silicon Valley. A new breed of "relational" venture capitalists seeking to buttress venture investments with strategic alliances may well displace them.

STRATEGIC TRADE POLICY, THE THEORY OF THE MULTINATIONAL ENTERPRISE, AND FOREIGN DIRECT INVESTMENT

MAINSTREAM ACADEMIC RESEARCH has, so far, contributed very little to our understanding of the motivation behind and the effects of foreign direct investment in high-technology industries. The most recent flurry — the literature on strategic trade and investment policy in the presence of oligopoly — is, unfortunately, no exception (see R. G. Harris in this volume). The new strategic trade theory contends that under a rather restrictive set of assumptions, nation states can intervene in markets to shift rents from foreign firms to domestic firms. Oligopoly theory is almost useless in helping us understand what is going on with respect to trade and foreign investment involving Silicon Valley firms.

The technological rivalry which unquestionably exists between American and Japanese firms is not primarily about the division of monopoly profits in identifiable product markets; rather, it is about the accumulation of firm-specific capabilities. Until the theory of trade and investment is able to build a meaningful model of the business enterprise, academic and policy research in this area will continue to flounder. It has been suggested (by Teece, Pisano and Shuen, 1990) that a firm should be represented by the capabilities it possesses and its capacity to employ and augment them, not by production functions and cost curves. It must also be recognized that a firm's resource endowments are substantially "sticky": i.e., firms are often "stuck" with what they have and may be equally "stuck" with what they lack, at least in the short term. Moreover, some kinds of asset are simply not readily tradeable. Certainly, tacit know-how falls into this category. Differences in capabilities, therefore, cannot easily be arbitraged away through factor markets or through the market for know-how. The market for corporate control — as with foreign direct investment — may provide certain, though limited, opportunities for transferring know-how and capabilities. If such investments are coupled with long-term efforts to build relationships and transfer technology, capabilities can generally be transferred.

If control over idiosyncratic capabilities can be the source of (Ricardian) rents, then it follows that such issues as skill accumulation and learning become fundamental to building firm-level competitive advantage. Foreign direct investment must be understood in this context. In short, it is not monopoly rents that are at issue in foreign direct investment, rather it is the Ricardian and Schumpeterian rents flowing from the gradual transfer of firm-specific capabilities in production and innovation. Hence, earlier work on foreign direct investment which analyzed the relative efficiency of equity positions and licensing as the way to do business abroad (Buckley and Casson, 1976; Teece, 1981, 1985, 1986) may have missed an issue which is becoming increasingly important, at least in Silicon Valley — the roles played by foreign direct investment in the accumulation of technology and the development of the business enterprise.

The emerging theory of corporate capabilities (Teece et al 1990) includes concepts which, if adopted, promise to yield a better theory of foreign direct investment. Foreign direct investment cannot be well understood unless specific attention is given to the organizational requirements of the innovation process, including the need of pioneers to gain access to complementary assets (Teece, 1986) in order to be successful in bringing a new product or process to market. The dynamic capabilities approach to the business enterprise may help provide a framework to understand how foreign investment fits into business strategy and technological development. As John Dunning (1989) suggested: "It is to be hoped that the next generation of scholars will give more attention to issues of innovation and entrepreneurship as they impinge upon the internationalization of business.".

POLICY ISSUES

SHOULD AMERICAN FEDERAL AND STATE GOVERNMENTS be encouraging or discouraging foreign investment in Silicon Valley? What are the benefits, and what are the costs? The answers to these questions are not at all straightforward. Nevertheless, I shall begin simply — with the presumption that there should be no restrictions on foreign direct investment. This is not quite the policy of the U.S. government at present, in that at least two avenues are currently available to restrict foreign direct investment — Exon-Florio and the anti-trust laws.

Following the Fairchild Fujitsu debacle discussed earlier, the Exon-Florio amendment[19] was passed which authorizes the pre-existing Committee on Foreign Investment in the United States (CFIUS) of the executive branch to intervene in foreign acquisitions of U.S. companies when such acquisition might imperil "national security". The law does not explicitly define this term, nor does it provide any examples of adverse effects. CFIUS has not been at all activist and has been criticized for its liberal stance.[20] In the context of CFIUS's controversial approval of the sale of Semi-Gas to Nippon-Sanso, the President's Science Advisor, D. Allan Bromiley, on August 14, 1990 is reported to have written the Department of Defense warning of the cumulative effect of CFIUS approvals. CFIUS has apparently approved 28 foreign acquisitions of semiconductor equipment and materials firms. Bromiley is reported to have argued that "our technological base can be nibbled from under us through the coherent plan of [foreign] purchasing of entrepreneurial companies, many of whom have been assisted directly or indirectly by the federal government in developing their technological strengths".[21] The Deputy Assistant Treasury Secretary meanwhile argued that the Nippon-Sanso acquisition would benefit the industry in the United States because of the capital investment and technology transfer that the Japanese company would make to Semi-Gas.[22]

The other mechanism available to block the foreign acquisition of an American company is the anti-trust laws, again illustrated by the Semi-Gas debacle. The Department of Justice (DOJ) and the Federal Trade Commission (FTC) both have the authority to block acquisitions by either domestic or foreign firms when the effect is to lessen competition substantially. In the Semi-Gas case, Congressmen Bingamen and Bentsen lobbied the DOJ arguing that if the acquisition went through, Nippon-Sanso could dominate the world market in critical semiconductor gas distribution systems. The Department of Justice *Merger Guidelines* (revised 1984) clearly specify the level of concentration required to warrant a challenge to a merger. However, the market definition approach, which the antitrust agencies also employ, need not of course exclude substitute products based on alternative technologies from the definition of the relevant market. At the time of writing (November 1990), the Semi-Gas acquisition is still pending.

I believe it is necessary, at least in the context of foreign direct investment in Silicon Valley, to adopt a forward-looking posture which examines the impact of FDI on the dynamic capabilities of American firms. If, by considering the evidence, this is resolved positively, it is probably the case that U.S. welfare is enhanced by FDI and vice versa. Certainly, the narrow consumer-oriented approach embedded in the antitrust laws is unlikely to capture all of what ought to be considered. Clearly, this is an area that invites careful empirical scholarship that examines the impact of FDI on skills and capabilities.

One of the consequences of an aggressive program launched recently by the Japanese to set up labs in Silicon Valley and elsewhere[23] may be that the stage is already set for a major debacle in 1991. Leading Japanese computer and electronic companies are opening labs in the United States and competing for top talent. NEC has already opened a research lab in Princeton; Matsushita is reported to be opening a new lab in San Francisco in 1991; and Canon in Stanford, California. The Japanese appear to be targeting sites near universities with leading computer science departments — hence the two proposed labs in the San Francisco-Bay Area. If the Japanese characteristically offer top dollar to attract talent, it will strain American universities and research facilities.

If these new labs focus on basic research, the world scientific community will be the beneficiary, because the technology will simply leak out. However, if the labs develop a strong proprietary focus, the effect may well be to deplete the United States of one of its few remaining competitive advantages in high technology — the clear superiority of its basic research. The ability of the Japanese to bring ideas to market will be further enhanced by such labs, but the distributional implications are by no means clear.

CONCLUSION

FOREIGN DIRECT INVESTMENT IN SILICON VALLEY has important implications for American economic welfare today because it is the arena where the global competition of the future is being shaped. Flaws in the Silicon Valley industrial system — the absence of ready access to patient capital, the lack of manufacturing skills, and poor access to foreign markets — mean that high-technology companies that are launched there frequently land elsewhere, at least, they need help staying aloft. This is a natural consequence of global competition — natural in the sense that it reflects the competitive advantage of the firms and nations engaged in global competition.

Is there cause for alarm? Perhaps so. Significant foreign investment in American high-tech firms signals the inability of such firms to grow to maturity without the infusion of capital and other resources from elsewhere. It also signals tremendous dynamic capabilities in early-stage technological development — followed frequently by subsequent failure. It is unlikely that the solution is to impede the flow of foreign investment. Rather, it is to build the infrastructure — education, skills, savings, employee commitment and the like — and new organizational systems that will support the development of later-stage capacities in the innovation process. Failure to do will only make it easier for foreign firms to profit disproportionately from the pioneering activity for which "the Valley" is so famous.

ENDNOTES

1. The traditional venture capital funds in which investors rely on an agent, the venture capitalist, to allocate venture monies across portfolio companies, does not facilitate a relationship or alliance-building between investor and investee. Indeed, the venture capitalist sometimes serves to impede rather than facilitate the flow of information and people between investor and investee.
2. G. Kirk Raab, Genentech's CEO, noted that "The quarterly pressures of the stock market, although real and understandable, were inevitably going to inhibit our taking advantage of the wonderful brain trust that works here on this 36 acres in South San Francisco." *San Jose Mercury News*, February 12, 1990.
3. The Genentech deal was valued at more than U.S. $4 billion — 100 times 1989 earnings.

4. 1989 revenues were $400.5 million; profits were $43.9 million.
5. Genentech founder and former CEO Robert Swanson collected $67 million on the transaction, while still keeping a large portion of his stock.
6. Wyse was hurt in 1988 particularly by Compaq's introduction of a 30386-based machine at 30286 prices and by IBM's re-entry into the PC-AT market with a low-priced machine.
7. According to Daniel Wu, the consortium's president-designate of Wyse, the consortium was named Channel International Corporation to reflect investors' belief that Wyse's prime asset is its well-established U.S. marketing channel (*Far Eastern Economic Review*, December 28, 1989).
8. According to Colley Hwang of the Market Intelligence Centre (MIC), Mitac will obtain a share of the 30 percent average mark-up distributors place on PC products (*Asian Business*, May 1990).
9. Founded by the late Robert Noyce, much of the early research leading to the microelectronics age was done at Fairchild in the late 1950s and 1960s. This included the Integrated Circuit.
10. Charley Clough, president of Wyse Labs, quoted in *Electronic News*, November 3, 1986, p. 10.
11. *Electronic News*, February 24, 1986, pp. 72-75.
12. Quoted in *Electronic News*, March 30, 1987, p. 10.
13. According to a member of the Committee for Foreign Investment in the United States (CFIUS), which spent weeks reviewing the Fujitsu proposal, "The reasons [for blocking the Fujitsu deal] varied from week to week" (*San Jose Mercury News*, September 7, 1987).
14. William Hart, general partner at Technology Partners, is one of three venture capital companies that had put $9 million into Akhasic.
15. Quoted in *Tokyo Business Today*, November 1989, p. 23.
16. In a recent paper, Frankel (1990) argues that while the cost of capital has generally been lower in Japan than in the United States, recent increases in interest rates or declines in stock values in Japan have left the cost of capital there approximately as high as in the United States.
17. See Teece, Pisano and Shuen (1990) for a discussion of the dynamic capabilities approach to strategic management.
18. Many large American companies are similarly afflicted with a lack of entrepreneurial capacity. However, there are more mechanisms available in the United States to counter this deficiency, other than an equity play in Silicon Valley. For the Japanese, links to Silicon Valley firms often provide a unique capacity to identify new technologies.
19. Exon-Florio was an amendment to the Omnibus Trade and Competitiveness Act of 1988.
20. As of February 1990, 270 cases had come before CFIUS. Seven of these cases were investigated, four recommendations were referred to the President, and one foreign investor, a Chinese national firm, was ordered to divest its share in a U.S. aerospace firm.

21. Quoted in *Electronic News*, October 15, 1990.
22. Ibid.
23. See "Japanese Computer Labs in the U.S. Are Luring America's Top Experts", *New York Times*, November 11, 1990, p. 15.

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DISCUSSANT'S COMMENT

DISCUSSANT:
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DAVID TEECE'S FINE ARTICLE is based on early results of a large scale research project. Even so, the article raises major issues and provides new insight into them.

Of all the facets of the current debate over foreign direct investment in the United States, nothing seems to raise hackles in Washington (and elsewhere in the United States), more than the acquisition of American high-technology firms by foreign firms. Such an acquisition (the attempted takeover of Fairchild Semiconductor by Fujitsu, discussed by Teece) prompted the passage of the Exon-Florio amendment of the 1988 Omnibus Trade and Competitiveness Act, which gave the President of the United States new authority to block takeovers of American firms by foreign investors if these threaten to impair the national security. Since its passage, this amendment has been the subject of continued controversy; critics maintain that the authority has been too little used, and that takeovers that clearly could (and, in the critics' view, should) have been blocked, have been allowed to proceed.

I am currently conducting an investigation of Exon-Florio. One of my findings is consistent with those of Teece — notably, that for virtually every transaction subjected to an Exon-Florio investigation and subsequently approved, two major factors have influenced the granting approval. First, the American party to the transaction has been faced with financial constraints that prevent it from fully exploiting the potential available opportunities. Most often, the constraint translates into an inability to commercialize technologies held by the firm. Second, no American buyer has been willing to acquire the American party on terms equal to those offered by the foreign party. The conclusion of the CFIUS in these cases has generally been that national defence interests are better served by allowing the American party to come under foreign control than by disallowing the transaction and risking the failure of the firm.

Teece hints that a significant factor behind the takeovers of many American high-technology firms by foreign investors (mostly, but not exclusively, Japanese firms) is the market failure of quite large proportions. For whatever reasons, Teece provided what I now consider a standard list (greater willingness of Japanese investors to take long-term risks associated with new business opportunities than American investors, less need on the part of managers of large Japanese firms to pay dividends or otherwise satisfy investors' demands, etc.) but rightly, in my view, debunks the cost of capital differences (foreign firms are often willing to invest more resources into developing new technologies than are their domestic rivals in the United States). This is consistent with the experiences of the CFIUS. Clearly, the American firms that have been party to CFIUS investigations have value, because foreign investors are willing to pay attractive prices to acquire them. But there seems to be a systematic difference between the valuation placed on these firms by foreign and by domestic investors; that is, the firms are valued more highly by the former than by the latter. Neither Teece nor I can, however, demonstrate conclusively that the market failure actually exists or that it is such that American investors systematically undervalue these firms (it is also possible that foreign investors overvalue them) but we share an uncomfortable feeling that this is, in fact, the case. Indeed, I share Teece's hunch that market failure occurs *inter alia* in financial markets. After all, how else can one explain a high-technology sector apparently starved for capital coexisting with billions of dollars available for bad real estate deals and leveraged buyouts during the middle 1980s? But a hunch is not a proven fact. Teece's article, in my view, provides compelling evidence and argument to support the hunch, but both fall short of being conclusive.

There are strands in Teece's article that arguably are less than robust. For instance, he builds a case for his "technological accumulation" theory as a superior alternative to the currently in vogue "internalization" theory of foreign direct investment as an explanator of acquisitions of American high-technology firms by foreign investors, noting that the policy implications of his theory are significantly different from those of the latter. I question whether the key ideas of "technological accumulation" really are as different from those of "internalization" as Teece suggests. "Internalization" is, after all, about the economies of internal exploitation of firm-specific, largely intangible assets, and it has long been noted that technology is one of the most important of these assets. "Technological accumulation" might then be seen as a useful adjunct to "internalization" rather than as an alternative theory. This in not the place to go into these matters in detail, but let me note that Teece's ideas might lead to a more dynamic version of internalization theory than we have seen to date.

Likewise, Teece claims that his is a theory of entrepreneurship, which is more useful in explaining foreign direct investment in the high-technology sectors than theories based on the behaviour of oligopolistic firms. Maybe so, but the acquisitions he describes involve large, oligopolistic firms (the investor firms from Japan and elsewhere) as wall as smallish, entrepreneurially-driven enterprises from California's Silicon Valley. It strikes me that abandonment of what we think we know about the behaviour of oligopolists is not entirely prudent in an examination of these acquisitions. Again, Teece's theory might better be seen as a complement to theories based on oligopoly rather than an alternative.

The policy implications of "internalization" theory for these acquisitions might, indeed, be different from those Teece draws. For example, the specific cases studied by Teece might prove simply to be ones where the acquired firm better fits the requirements of a foreign firm to implement its strategy than those of any other domestic firm (hence, the apparent premium the foreign investor is willing to pay over the price offered by a domestic investor); there might be other cases, not included in this study, where domestic firms acquired domestic high-technology firms, paying prices in excess of those offered by any potential foreign buyer, for much the same reasons. If so, there is rather less to worry about than Teece suggests. But much the same story could be told simply by recasting Teece's own variant of the theory, and the implications would also run against those Teece wants to emphasize.

Despite my critical comments, my own biases run much more with Teece than against him. I am happy to see that in this version of his paper, Teece has backed away from a suggestion made in an earlier draft that one remedy to this failure might be a more interventionist direct investment policy in the United States. Even if the "first best" outcome is judged to be that these high-technology firms continue to develop under American ownership (where "continue to develop" implies freedom from the financial constraints they currently face) it does not follow that the United States should block foreign takeovers of such firms. Such blockage may do little more than cause these firms to wither and die — a point not lost on the CFIUS. The "second best" alternative, then, might very well be to allow foreign investors to acquire these firms. The result as the critics note, will be that managerial control over the technologies developed by the firm will no longer be in the hands of American citizens, but at least the technologies will be developed and the standard of living of American residents will also be improved as a result. The way to the "first best" does not lie in a restrictive direct investment policy, but rather to a comprehensive examination of why the apparent market failure is happening and, based on this examination, a remedy to the root cause of the failure.

Overall, while I don't think that he has made his case beyond any reasonable doubt, I do think that he has made a case that must be taken very seriously. As I noted at the beginning of this commentary, the present article is more a proposal for research into to area of foreign acquisition of high-technology firms in the United States than a final report. One looks with anticipation towards the results of further inquiry.

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9

Foreign Acquisitions of Canadian High-Technology Firms

INTRODUCTION

THE UNDERLYING CONCERN of this paper is the domestic social welfare implications of foreign acquisitions of Canadian-owned "high-technology" companies. A related concern is whether government intervention into the acquisition process can be expected to improve Canada's economic welfare, and the conditions under which this is likely to be so.

The Canadian government has displayed a cyclical attitude toward foreign direct investment (FDI), partly related to domestic macroeconomic conditions.[1] The replacement of the Foreign Investment Review Agency by Investment Canada in 1985 signalled a significant change in the attitude of the Canadian government toward foreign direct investment. Specifically, the review process was streamlined to reduce both the scope of investments subject to review as well as the time and resource obligations imposed on foreign investors to obtain approval of their applications. In addition, the *Investment Canada Act* altered the nature of the criteria used to assess investment proposals. Specifically, investors are required to demonstrate that their investments will provide "net benefits" for Canada rather than "significant benefits" as required under the *Foreign Investment Review Act*. Investment Canada also initiates and coordinates investment promotion activities.[2]

It is difficult to evaluate the impact of the review process under either the *Foreign Investment Review Act* or the *Investment Canada Act*, although it is clear that direct disapprovals by Investment Canada (or by its predecessor) have had a very minor influence on the direct investment process.[3] The fact that since June 30, 1985, Investment Canada has approved all renewable acquisitions is a continuing source of concern for some Canadian nationalists. This concern has been expressed more broadly in the media with reference to foreign acquisition of Canadian "high-technology" companies. Recent cases include the sale of Connaught Bio Sciences to Institut Merieux and the sale of Nova Corporation's rubber division to Bayer A.G.[4] The sale of de Havilland to

Boeing Corporation was perhaps the most controversial recent foreign acquisition of a Canadian-owned high-technology company.

Concerns about foreign takeovers of domestically owned high-technology companies are expressed in several forms. One concern is related to a long-standing argument that foreign ownership inhibits innovation and technological change in Canada.[5] A second concern is rooted in a view that domestic taxpayers should be compensated for subsidies that have been extended to the acquired companies and that such compensation is not typically forthcoming in the acquisition process.[6] A third concern suggests that acquisitions lead to increased monopoly power in the relevant industries with no significant efficiency benefits.

These concerns all imply a potential need for public policy intervention in the foreign acquisition process, especially for domestic high-technology companies. This paper considers whether such acquisitions are likely to reduce the economic welfare of Canadians and whether government intervention can enhance the domestic net benefits associated with foreign takeovers of domestic firms. The criterion of welfare improvement is producers' plus consumers' surplus as approximated by the change in the monetary wealth of Canadians. The paper proceeds as follows: the second section presents some statistical evidence on the nature and magnitude of the foreign acquisition process by way of background; the third section considers potential reasons for foreign acquisition of Canadian-owned high-technology companies and the implications of these reasons for public policy; the fourth section presents and discusses case study evidence bearing upon the acquisition process; the fifth section evaluates the implications of R&D externalities for government policy toward high-technology acquisitions. Finally, the sixth section provides a summary and concluding comments.

FOREIGN ACQUISITIONS IN HIGH-TECHNOLOGY INDUSTRIES

THIS SECTION SUMMARIZES some of the available evidence on foreign acquisition of Canadian high-technology companies as background to our economic evaluation of the phenomenon. The evidence is intended to provide some perspective on foreign acquisition activity and to highlight several important characteristics of the phenomenon that may be relevant to an evaluation of the resulting economic consequences.

It must be noted at the outset that while the definition of a high-technology industry has an obvious bearing upon the data chosen for analysis, any definition is subject to dispute. In principle, technology is a factor of production along with more conventional aspects such as labour and capital. Technological intensity might therefore be measured as the share of factor payments going to "technological" factors of production. This begs the obvious question of how to define technological inputs. Many studies rely upon narrow input definitions such as research and development intensity or share of total

TABLE 1

CONCENTRATION OF PATENTS BY STANDARD INDUSTRIAL CLASSIFICATION (SIC) OF MANUFACTURE

INDUSTRY	PERCENTAGE OF ALL PRODUCT PATENTS	
	1978/79	1984/85
1. Fabricated Metals	8.5	5.8
(i) Other metal fabricating (309)	2.9	1.4
(ii) Hardware, tool & cutlery (306)	2.0	1.0
(iii) Stamped metal productes (304)	1.0	1.0
(iv) Ornamental metal products (303)	1.0	0.4
(v) Heating equipment (307)	1.0	0.9
(vi) Wire and wire products (305)	0.6	0.3
2. Machinery	26.3	18.6
(i) Other machinery and equipment (319)	24.5	17.5
(ii) Agricultural implements (311)	1.3	0.8
(iii) Commercial refrigeration (312)	0.4	0.3
3. Transportation	5.5	3.6
(i) Motor vehicle parts (323)	3.7	2.4
(ii) Railroad rolling stock (326)	0.6	0.4
(iii) Others (321, 324, 325, 327-29)	1.2	0.8
4. Electrical Products	21.0	22.8
(i) Communication equipment (335)	11.0	10.7
(ii) Electrical industrial equipment (337)	3.3	5.1
(iii) Office, store and business machinery (336)	2.5	2.3
(iv) Electric lighting (333)	1.7	0.5
(v) Record players, radio and t.v. receivers (334)	0.6	1.4
(vi) Other electrical products (339)	0.9	1.7
(vii) Others (331, 332, 338)	1.0	1.1
5. Chemical Products	17.7	16.7
(i) Industrial chemicals (371)	7.8	6.0
(ii) Other chemical products (379)	4.0	3.7
(iii) Plastic and synthetic resins (373)	2.8	2.4
(iv) Pharmaceuticals (374)	1.7	2.5
(v) Paint and varnish (375)	0.6	0.8
(vi) Others (372, 376, 377)	0.8	1.3
6. Scientific and Professional Equipment	6.9	6.9

SOURCE: PATDAT series, various years

employment of scientists and engineers as indices of technological intensity. The problems with using input measures such as R&D are well-known and will not be discussed here.[7] Other studies have tried to identify technological intensity by focussing on "output" measures such as patenting activity or the rate of new product introduction. Such measures are also subject to well

TABLE 2

FOREIGN ACQUISITIONS OF DOMESTIC HIGH-TECHNOLOGY COMPANIES 1985 - 1989

INDUSTRY	SIC	1985[a]	1986	1987	1988	1989[b]	ALL YEARS
1. Compressors, pumps & industrial fans	3191			2		1	3
2. Construction & mining machinery	3192			5	1		6
3. Turbines mechanical power transmission equipment	3194				1		1
4. Other machinery & equipment	3199	2		1	1	1	5
5. Aircraft & parts	3211	1	1		2		4
6. Record players, radio & t.v. receivers	3341		1				1
7. Telecommunications equipment	3351		2	1	1		4
8. Electronic parts & components	3352	1	1	1	2		5
9. Other commuications & electronic equipment	3359	1	2	2	2		7
10. Office, store & business machines	3360		2	3	2		7
11. Electrical transformers	3371		1			1	2
12. Other electrical industrial equipment	3379				2		2
13. Communications & energy wire & cable	3381					1	1
14. Batteries	3391	1	2				3
15. Industrial chemicals	3710		3	5	1	1	10
16. Plastic & synthetic resins	3731			1	1	1	3
17. Pharmaceuticals	3741		1	1	1		3
18. Indicating, recording & controlling instruments	3911			2	3	1	6
19. Other instruments	3912		2		1	1	4
		6	18	24	21	8	77

a) from June 30th

b) to June 30th

known criticisms, including the argument that patent counts or counts of new product introduction may bear no reliable relationship to the commercial value of the underlying technology.[8]

In view of the problems associated with individual input or output measures of technological intensity, several measures must be considered in an effort to "bracket" the range of industries that are relatively technologically intensive. While the choice of industries will be influenced at the margin by the specific measures chosen, conventional input or output measures tend to identify a similar broad set of manufacturing industries as being technology-intensive.[9] In this regard, the identification of industries on the basis of patent data, as in Table 1, probably provides a representative definition of the set of relatively technology-intensive industries. The important point to note here is that a relatively small number of industries, i.e. electrical products, chemical products, scientific and professional equipment, transportation equipment and machinery account for virtually all, that is between 75 percent and 85 percent of, domestic product patents. They also account for the bulk of R&D expenditures and employment.

Table 2 reports acquisitions of Canadian businesses in the period from June 30, 1985 to June 30, 1989 that were subject to the *Investment Canada Act* and that were classified by Investment Canada as being in the high-technology sector. The data are set out by four-digit SIC code. All of the acquisitions reported in Table 2 involved Canadian companies, or divisions of Canadian companies, classifiable to an SIC code identified in Table 1. That is, the acquisitions identified by Investment Canada would satisfy most conventional definitions of acquisitions having taken place in a high-technology industry although there is no way of definitively concluding that they involved a high-technology company.

Over the entire period, 77 foreign acquisitions of high-technology companies in Canada took place. About 42 percent of the acquisitions involved companies in the electrical and electronics products industry; approximately 21 percent were in the chemical products industry and 19 percent involved companies in the machinery industry. Another 10 percent involved acquisitions of instrumentation companies. The industrial distribution of acquisitions is somewhat different from the size distribution of the industries cited. For example, gross domestic product originating in the electrical and electronic products industry was approximately three times higher than gross domestic product originating in either the machinery or chemicals industry in 1988 and was almost ten times greater than gross domestic product originating in the scientific and professional equipment sector. Hence, acquisition intensity is lower in the electrical and electronics products industry than in the other industries represented in Table 2.

There is also a temporal component to the acquisition activity over the sample period. Specifically, acquisition activity appears to have increased progressively through 1987 and then declined consistently thereafter. A different database of acquisition activity points to a similar temporal pattern. Specifically, the Venture Economics Database of acquisitions of Canadian high-technology companies shows acquisitions decreasing consistently in absolute number from around 107 in 1986 to 50 in 1989. This series is summarized in Table 3. The most active acquisition years were 1985 and 1986.[10]

The Venture Economics Database is presumably broader than the Investment Canada series inasmuch as it theoretically encompasses all acquisitions of high-technology companies by either Canadian-owned or foreign-owned companies. Moreover, it theoretically includes acquisitions that may not have been reviewable by Investment Canada. As such, the two series are not directly comparable and it is unclear how much can be inferred from observed differences between the two series in the temporal patterns of acquisition activity. Given that foreign acquisitions may be delayed by the approval process, whereas domestic acquisitions should not be, it might be concluded that the earlier "peaking" in the Venture Economics series reflects a shorter lag for domestic acquirers between the time a decision is taken to make an acquisition and the time the acquisition

TABLE 3
VENTURE ECONOMICS DATABASE

	1985	1986	1987	1988	1989	ALL YEARS
Number of Acquisitions of Domestic High-Technology Companies	103	107	89	74	50	423

	COUNTRY OF ORIGIN BY PURCHASES 1985 - 1989				
	CANADA	U.S.	U.K.	JAPAN	OTHER
Number of Acquisions	176	166	28	6	45

is resolved. In this regard, it might be noted that the date indicated for the Investment Canada series is the date of resolution of the acquisition.

Total foreign acquisitions were a relatively small proportion of all acquisitions of manufacturing companies by foreigners over the period 1986 through 1988. For example, the acquisitions shown in Table 2 for the years 1986 - 88 constituted around 12 percent of all reviewable manufacturing acquisitions over same period. American investors accounted for around 63 percent of the acquisitions reported in Table 2 which is quite comparable to the 67 percent that American investors accounted for in the case of all reviewable manufacturing acquisitions. The latter is also virtually identical to the 68 percent of total foreign acquisitions by the United States reported in the Venture Economics series. This implies that in terms of the national identity of foreign acquirers, high-technology acquisitions do not look much different from manufacturing acquisitions broadly defined.

Finally, the two series taken together suggest that high-technology acquisitions may be somewhat larger than acquisitions in the manufacturing sector broadly defined. For example, for a subset of reported foreign acquisitions, the Venture Economics series indicates that the average value of a foreign high-technology acquisition is around $112 million. For all reviewable manufacturing acquisitions over the period 1986 - 88, the average value is around $30 million. This result seems somewhat surprising given the expectation that high-technology companies would be smaller, on average, than manufacturing companies. However, it must be noted that the Venture Economics series is heavily influenced by three unusually large foreign acquisitions: General Electric's acquisition of the minority shares outstanding of its Canadian subsidiary; the acquisition of Connaught Bio Sciences by Institut Merieux and the acquisition of the latex division of Polysar Energy by BASF AG. If these three acquisitions are excluded, the average value of a foreign acquisition declines to around $40 million.

In summary, notwithstanding several relatively large acquisitions of high-technology companies by foreign investors, foreign acquisitions of such companies account for a relatively small share of all acquisition activity. Moreover, broad characteristics of high-technology acquisitions including their timing, nationality of acquirer and size, seem comparable to acquisitions in other manufacturing industries. To this extent, there is a suggestion that the motivations for and the welfare implications of high-technology acquisitions are comparable to those of a broader range of mergers and acquisitions. However, before accepting this conclusion, it is worth examining more fully the potential for differences to exist between different types of acquisitions.

THE VALUATION GAP

THE WELFARE IMPLICATIONS of high-technology acquisitions by foreigners may differ from those of other acquisitions to the extent that shareholders in acquiring companies fare differently from those in acquired companies. Specifically, the empirical literature on mergers and acquisitions suggests that relatively little, if any, economic rent is earned, on average, by acquiring shareholders. To the extent that foreigners earn economic rent on high-technology acquisitions in Canada, there may be an argument for government intervention to transfer some or all of the rent that might be earned by foreign acquirers to domestic shareholders or other domestic factors of production. On the other hand, to the extent that foreign acquirers typically pay close to their reservation prices for domestic high-technology assets, there is little scope for intervention to boost the effective price of the acquisition either directly or indirectly.

It should be noted at the outset that Investment Canada does not see itself playing an explicit rent capture role in its review process. Rather, the agency sees itself as practising due diligence in reviewing an investor's business plan. However, in a small number of cases an undertaking on the part of investors may be required to win approval. In other cases, investors may incorporate undertakings into their proposals prior to review, in order to increase the possibility of approval. In this context, certain activities or actions may be elicited from foreign acquirers that would not otherwise be realized in the absence of a review process. If these actions or activities enhance the wealth of Canadians (broadly defined) and if they imply no decrease in wealth for other Canadians, Investment Canada will have indirectly generated rent for Canadians.

Roll summarizes the wealth effect of mergers and acquisitions on the bidding firm as being generally small in percentage terms and generally much smaller than target firm returns. However, the results are variable depending upon the sample, the period and the "biases of the reader". Moreover, return to the bidding firm may reflect more information than just the interest in making a takeover, for example, it may say something about the bidding firm's cash flow.[11] In a similar vein, Eckbo presents evidence on the relative performance of bidder and target firms in foreign versus domestic acquisitions in Canada over the period 1964 - 83. The evidence indicates that bidders acquiring firms listed on the Toronto Stock Exchange on average earn significant gains from takeover activity; however, bidder firms listed on the New York Stock Exchange earn zero average abnormal returns from the transactions when they acquire Canadian firms.[12]

An example of Investment Canada's negotiation of undertaking is provided by Institut Merieux's merger with Connaught BioSciences. Merieux undertook to spend $15 million over 10 years on research in Canada if it succeeded in its merger with Connaught. The University of Toronto will receive $9 million while institutes, universities and granting councils will receive a further $6 million.[13] The commitment, coming as part of the Investment Canada approval process, seems to suggest that Merieux did not pay (up to) its reservation price in its original bid to Connaught shareholders, and that the lengthy approval process was instrumental in squeezing some additional payment from Merieux. This claim will be addressed below when a number of case studies bearing on the high-technology acquisition process in Canada are considered. At this point, the theoretical question is why foreign acquirers are able to outbid Canadian investors for domestic high-technology assets while expecting to earn positive net returns from their acquisitions.

The basis of a foreign acquisition of a set of domestic assets is a valuation gap. Specifically, to a foreign investor the expected present value of the assets exceeds the expected present value of the assets to all Canadian investors. The potential sources of the valuation gap can be identified with reference to a simple formulation of the present value equation:

$$E(V)1 = E(R_1 - C_1)/(1 + r)$$

where all cash flows occur at the end of period one; R is a vector of possible incremental revenue streams associated with operating the assets in question; C is a vector of the associated costs; r is the investors' cost of capital; V is present value and E is an expectations operator. Expectations in this case pertain to the probabilities attached to different economic and political conditions that can influence the cash flow streams generated from a set of assets.

The following discussion will be made clearer by acknowledging several expected value concepts:

(i) E(V)f is the expected value to a foreign investor;
(ii) E(V)r is the maximum price foreign investors will pay for the assets in question. This would presumably equal $E(V)_f$ in the absence of capital rationing.
(iii) $E(V)_n$ is the expected value of the assets to domestic investors holding "rational" expectations about future states of nature, i.e. they have all available information and are not "unduly" pessimistic about future states of nature, where states of nature may be thought of as contingencies that influence the outcome of an investment.
(iv) E(V)d is the expected value of the assets to current domestic owners.

In this context, a set of domestic assets can be worth more to a foreigner than to a potential domestic investor for several reasons.

First, foreign investors have different expectations. Specifically, they are relatively more optimistic about "high payoff" states of nature compared to Canadian investors.

Second, foreign investors anticipate utilizing the relevant assets differently from Canadian investors such that the R and C vectors differ systematically across the two sets of investors. Specifically, the R vector is higher for foreign acquirers and/or the C vector is lower.

Finally, foreign investors have lower costs of capital than Canadian investors. Several possibilities exist here. One is that Canadian corporate investors have higher company-specific risk than do foreign corporate investors. Another is that capital markets are segmented so that foreign investors have access to lower-cost financing.[14]

To the extent that Canadian investors are unduly pessimistic about the future states of nature that condition the payoffs to different investments, more objective assessments on the part of foreign investors could encourage the latter to acquire assets from Canadians. In this case, a valuation gap exists because E(V)d is less than E(V)n. This would result in an implicit wealth transfer from shareholders of acquired domestic firms to shareholders (or managers) of acquiring foreign firms unless the foreign investor paid (up to) the reservation price, which is presumably at least equal to E(V)n. On the other hand, to the extent that foreign investors are unduly optimistic about the relevant future states of nature, the *ex post* prices they pay for Canadian-owned assets will prove to be too high and the explicit wealth transfer runs the opposite way.

It should be noted that when the valuation gap is rooted in undue pessimism on the part of domestic investors, a screening process that directly or indirectly discourages the foreign takeover may impose no real costs on society. That is, current investors may believe they would be better off selling out to foreigners, but experience will convince them otherwise. However, there is no plausible theoretical explanation of why Canadian investors would be systematically misinformed about the objective probabilities of future states of nature. Learning over time would presumably correct "irrational" expectations on the part of any group of investors, so that (on balance) there should be no unduly optimistic or pessimistic groups.[15] Perhaps of greater relevance, case study evidence discussed below suggests that in a significant number of cases foreign investors are ultimately disappointed in the financial performance of their Canadian acquisitions which is inconsistent with a notion that Canadian high-technology assets are usually bargain acquisitions for foreigners.

To the extent that foreigners can extract higher net revenues from a given set of assets, they would presumably outbid Canadian investors for those assets. In this case, the valuation gap $E(V)_f$ minus $E(V)_n$ might reflect real economies that could be realized from a transfer of ownership to foreigners. Whether foreign investors are forced to pay (up to) their reservation price for the assets acquired, ultimately depends upon the state of competition in the acquisition market; i.e. whether other foreign acquirers can also utilize the assets more efficiently than the current Canadian owners. Where there is workable competition in the acquisition market, a major share of the anticipated increased profits associated with more efficient use of the assets in question will be captured by shareholders of the acquired firm through the bidding process. Moreover, competition in product and factor markets might ensure that the bulk of any residual efficiency gains are passed through to final consumers or backwards to other domestic factors of production.

Here again, the main point is that there may be little rent available to be captured by a public review agency in the form of undertakings demanded of the foreign investor if the latter pays (up to) the reservation price.[16] This issue is ultimately an empirical one; however, the consequences of discouraging the acquisition either directly or indirectly are potentially different from the preceding case. To the extent that foreign investors can attain comparable economies by forming alliances with non-Canadian companies, discouraging foreign acquisition of Canadian-owned companies will put the latter at an increasing competitive disadvantage in international markets. As a result, the wealth of Canadian owners will decrease, i.e. $E(V)_n$ will decline in the limit to zero. Domestic shareholders will obviously be worse off than they would have been if there had been no review process. Moreover, real transactions costs will likely be imposed upon the domestic economy associated with reallocating unemployed resources into other activities.

On the other hand, to the extent that the higher net revenues associated with a foreign acquisition derive from enhanced market power, discouraging the acquisition may largely prevent a wealth transfer from domestic consumers to domestic shareholders. This presumes that the bulk of the output produced by the acquired firm is sold in domestic markets. Where the acquired firm exports a large share of its output, the welfare effects are more complicated. In the latter case, foreign consumers may bear the greatest share of the costs of the enhanced market power. In fact, the small average size of most high-technology acquisitions and the rapid rate of entry and exit in technology-intensive industries suggests that a market power motive for foreign takeovers will be the exception rather than the rule.[17]

The argument that venture capital is relatively scarce in Canada is a difficult one to deal with persuasively. There is certainly anecdotal evidence in support of the argument. Surveys of Canadian entrepreneurs in which concerns are expressed about the costs of financing, particularly bank financing, are one source of evidence.[18] More recently, the president of Alias, a Canadian software company, complained about the difficulties that small Canadian software firms have in negotiating loans from banks. He also noted that his company decided to issue shares in the United States because American markets are more receptive to technology issues, and it is less complex and less expensive to limit the public offering to the United States.[19] On the other hand, evidence that capital markets are becoming increasingly interdependent suggests that differences in the cost of capital among firms should be related to differences in firm-specific risk.

Certain characteristics of the acquisition process suggest that a cost-of-capital explanation for foreign takeovers of domestic companies is not very compelling.[20] For example, according to Venture Economics, almost 42 percent of domestic high-technology acquisitions over the period from 1985 through 1989 were made by Canadian-owned companies. It is not clear why these Canadian-owned companies were able to access capital markets at competitive costs in order to outbid would-be foreign acquirers, while acquired Canadian-owned companies were not able to access competitively priced capital in order to retain ownership. Furthermore, a number of the relatively large Canadian-owned firms that were acquired, including Mitel, Connaught BioSciences and Lumonics, were publicly-traded companies that had been successful in the past in raising equity capital on public stock exchanges and private placements. Why would their sale to a foreigner suddenly be forced upon them by capital market imperfections?

Although it is possible that a major expansion of a company that requires large additional amounts of financing might be more easily undertaken by raising funds from other firms in the same industry who are better able than "outside" investors to evaluate the returns and risks associated with the expansion, if there were no operating or strategic synergies associated with the change in ownership structure the foreign investor might be expected to adopt a passive role. That is, the investment would be treated as a portfolio investment. The evidence from the case studies to be discussed below suggests that the acquiring companies do not treat their acquisitions as passive investments and, indeed, that significant synergies are anticipated in integrating the two companies. In this context, foreign equity investment is a requisite input to achieving higher returns. Specifically, the acquiring company invests equity in a domestic firm to ensure that incentives to achieve potential synergies are compatible. Whether controlling interest is required to achieve compatible incentives is ultimately an empirical question that will no doubt vary from case to case.[21] The important point here is that the main underlying rationale for acquisitions is to capture potential real economies and not to fill a capital market gap.[22]

In short, artificial financing advantages enjoyed by foreign firms can contribute to a gap between E(V)f and E(V)d, although competitive bidding among foreign firms for the domestic assets in question could result in the financing advantage largely being capitalized in the acquisition price paid by the foreign investor. Moreover, the existence of domestic capital market gaps does not imply that foreign acquisitions should be discouraged. While preventing foreign acquisitions of Canadian companies would perpetuate domestic ownership in the short run, the long-run costs are likely to be substantial. For example, start-up ventures might be discouraged by not having access to lower-cost financing.[23] Indeed, discouraging inward direct investment would presumably exacerbate a capital scarcity problem facing all high-technology companies in Canada. Even higher costs of capital would put Canadian-based companies at an increasing competitive disadvantage compared to those based in other countries. The disadvantage would be particularly acute for those companies not affiliated with large multinationals and it would be more pronounced if real economies were attainable through the direct investment process. In this context, subsidy schemes seem to be a more appropriate policy to mitigate financing disadvantages faced by Canadian companies.

In summary, any foreign acquisition of a domestic company by definition implies that the expected value of the assets involved in their best use is higher to foreigners than to Canadian investors. Several possible explanations can be put forward for this valuation gap, with somewhat different implications for the likely welfare effects of government intervention. Specifically, if Canadian investors are systematically misinformed about the investment environment, there is the potential for foreigners to acquire domestic assets at prices that are "bargains" on both an *ex ante* and *ex post* basis. Of course, this conclusion would be mitigated by competition among foreign investors in the acquisition market who could bid up the value of domestic assets to a "fair" value. However, if the acquisition market is imperfectly competitive there is, at least in theory, the potential for the Canadian government to screen acquisition bids to ensure that foreigners do not take advantage of irrational expectations held by domestic investors. Nevertheless, both theory and evidence suggest that irrational expectations are unlikely to be a systematic cause of valuation gaps.

An alternative general explanation of the valuation gap is that it is associated with a more efficient use of resources. Specifically, the domestic assets in question promise a higher net cash flow if they are used in conjunction with a broader set of complementary assets owned by foreigners. Furthermore, the expected net cash flow is higher when the foreign investor internalizes the jointly-used assets rather than the domestic investor; i.e. it is more economical for the foreign investor to be the acquirer. Again, an absence of competitive bidding for the assets in question may result in the foreign investor paying less than the reservation price. In this case, the possibility again exists for the government agency to extract a higher net effective price in the form of undertakings; however, any such attempt by the government to extract a higher price carries the risk that the foreign acquirer will be pushed beyond its reservation price and abandon the bid. When the valuation gap is rooted in real efficiency gains rather than irrational expectations on the part of domestic investors, discouraging the foreign acquisition may leave the domestic firm in a weaker long-run competitive position by preventing efficiency-enhancing innovations that might accompany an ownership change. On balance, domestic shareholders and other factors of production may be made poorer in real terms by a deterioration in the international competitiveness of the enterprise.

Higher expected net cash flows under given states of nature may also be realizable by the acquirer if the acquisition increases the acquiring firm's ability to capture monopoly rents. In this case, the valuation gap is based upon pecuniary economies rather than real economies. If several foreign firms can benefit in this way, competitive bidding for the domestic assets in question could lead to most or all of the valuation gap being capitalized in the price paid to domestic shareholders. To the extent that the government agent tries to extract a higher price, it may discourage the investment. The welfare implications of discouraging the investment are, in this case, somewhat ambiguous. If most of the output produced would have been sold to domestic consumers, the acquisition would have resulted in a transfer of wealth from domestic consumers to domestic (and possibly foreign) shareholders. There would be no net domestic welfare gains associated with this acquisition. On the other hand, if the bulk of the output produced is exported, and if the price paid by the foreign investor exceeds E(V)d, domestic shareholders are made wealthier at the expense of foreign consumers. In this case, discouraging the foreign acquisition, either directly or indirectly, will impose income losses on Canadians, all other things constant.

It was argued above that many foreign acquisitions in high-technology industries are unlikely to be motivated by potential market failure gains. It should also be noted that the evidence surrounding the existence of efficiency gains to mergers and acquisitions is itself less than persuasive. The studies done for the Royal Commission on Corporate Concentration did not find evidence that efficiency gains were a ubiquitous feature of the acquisition process. Indeed, the available evidence suggested that such gains were difficult to identify in a large number of cases covering different industries.[24] Nor does the evidence for Canada seem much different from that for other countries. For example, Cowling, *et al* do case studies of various mergers in a variety of British industries. They conclude that efficiency gains from merger are not generally found.[25] They also caution that there are cases where market power has likely been enhanced by the merger. To be sure, several cases were identified where efficiency gains followed from a merger. These were cases where superior management gained control of the acquired firm's resources. It is potentially relevant to note that the computer industry in particular is identified as having benefitted from rationalization through merger. Specifically, the authors conclude that the British computer industry has been able to hold its own against American companies, and that this performance could not have been maintained if firms in the industry had not merged.

More persuasive evidence on the existence of efficiency gains from mergers and acquisitions is provided by Baldwin and Gorecki. The latter use plant-level data which are arguably more reliable than firm-level data in identifying the efficiency gains from mergers. They find that the merger process contributes to an important part of firm turnover and that the merger process improves productivity and profitability; however, there is a high degree of variability in the process, and it is primarily plants which are shifted from exiting firms to continuing firms that experience significant productivity and profitability improvement.[26]

In theory, it might be argued that efficiency gains associated with mergers are likely to be more prominent in high-technology industries. One possible reason is that rapidly changing technology makes it more likely that firms would find it beneficial to pool knowledge and other complementary assets both to reduce risk and to facilitate parallel research and development. Another reason is that rapid obsolescence of technology and other assets puts a premium on assembling a critical mass of organizational resources quickly. All other things constant, this would encourage mergers rather than internal growth. Moreover, less elaborate forms of cooperation, such as licensing agreements, are likely to be less attractive in high-technology industries, given well-known difficulties in contracting for new technology and in monitoring any resulting contracts.

Finally, higher financing costs encountered by domestic companies could contribute to a valuation gap that would encourage foreign acquisitions. To the extent that the acquisition market is competitive, government intervention can affect the nature of the acquisition premium paid but not the size of the premium. If government intervention discourages the acquisition, there may also be long-run costs imposed on the economy. Specifically, there could be a reduction in foreign inflows of capital as foreigners perceive a higher risk of approval failure. There may also be reductions in domestic savings going into start-up ventures in Canada to the extent that would-be investors see the rewards to start-ups reducing because foreign acquisitions will be discouraged. The net result is that domestic high-technology firms could be placed at an even greater financing disadvantage over time with adverse consequences for their competitive positions in international markets.

This leads to the conclusion that absent externalities, arguments for government intervention into the foreign acquisition process, turn largely on whether the acquisition market is competitive and the extent to which domestic companies would be competitively disadvantaged if foreign acquisitions were directly or indirectly discouraged.

In the section following I consider evidence from a set of case studies of Canadian high-technology acquisitions bearing upon the ostensible motives for the acquisitions as well as the consequences of such acquisitions.

EVIDENCE ON CIRCUMSTANCES SURROUNDING THE VALUATION GAP

IN THIS SECTION, I CONSIDER the experience of several takeovers of domestic high-technology companies. The examples include those that were covered in some detail by the media and are probably not representative of the size and nature of high-technology acquisitions in general. Nevertheless, since it is the large, high-profile acquisition that generates the greatest controversy, an examination of the associated experience is probably most relevant.

DE HAVILLAND

THIS REPRESENTS PERHAPS THE MOST CONTROVERSIAL SALE of a domestic Canadian company to a foreign purchaser. De Havilland was bought by the federal government from the Hawker Siddeley Group Ltd. of Britain. By the mid-1980s, the company was plagued by declining revenue and escalating debt and the federal government was facing the prospect of having to pump increased funds into the Company. In 1985, de Havilland was sold by the government to Boeing Corporation and the company officially became a division of Boeing of Canada on January 30, 1986.

It must be noted here that there was at least one official competing offer for de Havilland made by Rimgate Holdings Ltd. of Toronto. Rimgate headed a group of investors including the Dutch aircraft maker Fokker.[27] It is also reported that Northrop, Beech Aircraft and British Aerospace were all interested in de Havilland as well. Whether these competing bids were sufficient to push Boeing up to its reservation price, including the value of the undertakings it made to the federal government as a condition of purchase, cannot be determined. Opponents of the sale argued that with the bulk of the Dash 8 development costs already covered, whoever bought de Havilland was almost guaranteed to make money for a couple of years. They claimed that the government essentially "gave away" de Havilland.[28] In the event, de Havilland ostensibly failed to contribute any profits to Boeing Canada throughout the 1980s. Moreover, large development expenditures for a new aircraft were looming, since the Dash 8 was considered outmoded by 1989.[29] In this frame of reference, it is difficult to argue (with the benefit of hindsight) that Boeing got a bargain, or that its optimism was justified, that is, that the *ex post* return on its investment in de Havilland matched the return expected.

More evidence on these points is provided by the rumoured amount that Aeritalia of Italy and Aerospatiale of France were willing to pay Boeing to assume ownership of de Havilland. The speculation is a deal worth $200 million.[30] This compares to the estimated original price of $155 million paid by Boeing. The latter claims it has invested hundreds of millions of dollars in de Havilland since its purchase. While Boeing also received a substantial settlement from the federal government as part of a lawsuit, it seems fair to conclude that any *ex post* calculation would show that Boeing failed to increase its wealth with the de Havilland purchase.

At the time of the purchase, Boeing officials stated that they thought de Havilland's smaller commuter plane would complement Boeing's line of commercial jets in terms of joint marketing to customers that bought both types of planes, although there was no intention of Boeing taking over the marketing function from de Havilland. There was also a belief that Boeing would be able to transfer some of its manufacturing expertise to de Havilland to improve the latter's productivity.[31] In fact, there is evidence that productivity did increase in the de Havilland plant after the Boeing takeover, although apparently not as quickly as Boeing expected or would have liked. Difficulties with de Havilland's labour force were also apparently more severe than Boeing anticipated.

In summary, it is difficult to argue that Boeing's purchase of de Havilland represented an *ex post* bargain which is consistent with an interpretation that Boeing paid close to its reservation price. While synergies were anticipated and arguably realized, difficulties in reorganizing de Havilland were apparently greater than Boeing anticipated. As will be noted below, the federal government successfully extracted commitments from Boeing at the time of the de Havilland sale; however, it is less clear that the commitments will be fulfilled over time, particularly with a change of ownership.[32] Moreover, it might be argued that the original undertakings were discounted in the purchase price, and that rather than representing a net increase in purchase price, they represented a transfer of wealth from taxpayers to specific suppliers of factors of production.

MITEL

MITEL WAS FOUNDED IN 1973 by two former employees of Northern Telecom. Its sales soared from $5 million in 1977 to $43 million in 1980 and to $255 million in 1983. It is involved in the design, development, manufacturing and marketing of telecommunications equipment, principally micro-processor controlled subscriber switching equipment commonly known as private branch exchanges.

Mitel's rapid growth in the early 1980s was financed largely through a public share offering in late 1979. Mitel's shares were enthusiastically embraced by the investment community and there is certainly no basis to suggest that Mitel was victimized by a venture capital market gap at that time. However, by 1984, Mitel was losing money and was facing increasing competition in the market for its major product. Indeed, it lost money consistently from 1984 through 1988 with the largest loss coming in 1986. In early 1986, Mitel sold 51 percent of its treasury stock to British Telecom. Some observers believe that Mitel would not have survived without British Telecom's investment.[33]

Unlike the de Havilland case, there was apparently no widespread concern that British Telecom was obtaining control of Mitel at a bargain price. Indeed, experience shows that it was anything but a bargain. British Telecom's 51 percent stake, acquired for $320 million in May 1985, is now estimated to be worth about $90 million.[34] As in the de Havilland case, some synergies were seen to be present in the acquisition. Specifically, British Telecom apparently saw an opportunity to gain a marketing entry into North America for its manufactured equipment more easily than would otherwise be the case. At the same time, British Telecom was seen as being able to facilitate Mitel's expansion into the British market. As will be argued later, Mitel did eventually return to profitability under British Telecom's stewardship; however, British Telecom's ongoing efforts to sell its majority share suggests that the anticipated synergies were not as great as originally anticipated. Indeed, British Telecom management has indicated that Mitel no longer fits its current strategy of focussing on international telecommunications services.

LEIGH INSTRUMENTS

LEIGH INSTRUMENTS specialized in electronic, aerospace, communications and navigation equipment assembled in air and naval systems primarily for the Canadian Armed Forces. It was domestically owned until 1988 when it was sold to Britain's Plessey Company. The controlling Canadian shareholder apparently spearheaded a move to be taken over by the British electronic giant, a company he described as "an absolutely terrific fit".[35] The perceived fit was that Leigh would get access to Plessey's European markets and financing for research, while Plessey would get a toe-hold in the Canadian defence business, which was expected to take off with a buying spree for submarines.[36]

Less than two years after Plessey acquired Leigh, Plessey itself was taken over through a joint bid from General Electric Co. of Britain and Siemens AG of West Germany. Initially, General Electric Company, which also controls Canadian Marconi, a Leigh rival, had considered merging the Leigh and Marconi operations, but eventually decided against this in the face of mounting financial losses at Leigh and recent cuts in Canadian defence budgets.[37] Indeed, Leigh was forced into bankruptcy in the summer of 1990. Its Ottawa-based operations were acquired by CVDS Inc. of Pointe Claire, Quebec. CVDS makes telecommunications and air traffic control systems which are complementary to Leigh's products. Leigh's wholly owned subsidiary, Micronav Ltd., was seen as likely to be sold to IMP Group of Halifax and Canadian Marconi of Montreal. Participants in this acquisition also saw significant complementarities in the product fits.[38] Moreover, there were apparently some 35 bidders for the bankrupt company.[39]

While access to financing was a motivating factor for Leigh's interest in Plessey, it was not the only, nor indeed necessarily the most important, factor. As noted above, both firms were seen as possibly gaining from sharing marketing channels. Also, at the time of the Plessey acquisition, Leigh was apparently in good financial shape, although it was about to experience a string of disastrous cost overruns on a series of government contracts that would eventually help force the company into bankruptcy. At the time of Leigh's initial overture, it was anticipated that Plessey would take a 20 percent ownership stake to cement the strategic partnership; however, IMP Group Ltd. launched a hostile takeover bid. Plessey assumed the role of white knight and outbid IMP for control of Leigh in April 1988.

Again, there is no evidence that the bidding process resulted in Plessey gaining ownership of Leigh at a bargain price. Leigh's bankruptcy a relatively short time after the Plessey acquisition belies the notion of a bargain. Although some observers suggest that if Plessey had been concerned more about what was happening at Leigh and less about avoiding its own hostile takeover, Leigh's bankruptcy might have been prevented. Both the government and Leigh's partners in its major contract appeared surprised by the extent of problems in Leigh's design work.[40] It does not seem farfetched to suggest that Plessey also may have misconstrued the profitability outlook for Leigh's government contracts. Indeed, the president of the company apparently only became aware of the depth of Leigh's problems because of the demands by Plessey for exhaustive financial and operating information.[41]

LUMONICS

LUMONICS IS A MAJOR SUPPLIER of laser equipment. It was founded in 1970 and went public in 1980. Its main areas of business are materials processing, marking systems and other high-technology laser products. The company operated successfully for nearly 20 years before it was acquired by the Japanese conglomerate Sumitomo Heavy Industries Ltd. in March 1989. Although Lumonics was not in financial difficulty at the time of its acquisition, it had suffered losses in each of the preceding three years.

According to management, Lumonics was trying to compete in a global marketplace, but its sales of less than $100 million were not large enough to support worldwide marketing and research and development programs.[42] Lumonics management indicated that it had failed in a year-long search to find a Canadian company willing to make the investment needed to enable it to compete in the increasingly competitive laser market. Sumitomo was seen as an owner with deep pockets and a patient view toward the longer term. A private investor was sought rather than using the public equity markets because management felt a publicly owned company would have difficulty spending the money necessary to do sufficient research and development and still satisfy the (short-term) interests of public investors.[43] In March 1989, Lumonics announced that its directors had endorsed a takeover bid from Sumitomo at a premium of around 35 percent to its current price.

The Lumonics case would seem to indicate that there is a gap in the domestic capital market. In particular, emerging companies such as Lumonics may have difficulty obtaining equity capital either from the public market or from Canadian companies. In fact, Noranda Ventures, a subsidiary of the domestic resource giant Noranda, was the largest shareholder in Lumonics. To the extent that Noranda was willing to invest money at an earlier stage, the inference of a financing gap may be too strong. A more meaningful statement would seem to be that no Canadian company could provide the combination of financing and market access offered by Sumitomo. In this regard, Lumonics has a strong interest in building up business in Japan and the Pacific Rim.[44] In 1988, Lumonics signed a distribution agreement with Sumitomo that called for Lumonics to provide lasers, standard systems, components and technical and service support, while Sumitomo was to handle systems integration, installation and support, as well as sales and marketing. The president of

Lumonics did not expect the agreement to have much impact on short-term sales, but rather saw it as the beginning of a long-term commitment to do business with the Japanese.[45] Hence, Sumitomo also had the advantage of experience with Lumonics in preparing its bid.

There is no basis to infer that Sumitomo obtained Lumonics for what it believed was a bargain price. Nor is there available information to infer anything relevant based on post-acquisition experience. Taken together with the Leigh Instruments experience, the Lumonics case points to a perceived difficulty on the part of smaller companies to obtain the financing they need for long-term R&D projects through the public equity markets. This may not be a uniquely Canadian issue; however, the relatively small number of large, Canadian-owned high-technology companies may make it a matter of necessity for smaller Canadian-owned companies to seek larger partners outside Canada, particularly when enhanced access to overseas markets is an integral part of the companies' strategies.

MDI (MOBILE DATA INTERNATIONAL)

MDI WAS INCORPORATED IN 1978 in British Columbia. It makes mobile and portable data terminals and mobile data communications systems. At the time of its acquisition by Motorola Canada in 1988, it was a publicly traded Canadian company.

As in the case of Leigh Instruments and Lumonics, MDI was looking to undertake a significant expansion of its research and development program to launch itself into broader geographic markets. And as in the case of Leigh, there was at least one rival Canadian bidder for MDI's assets; BCE Mobile Communications, an affiliate of Bell Canada Enterprises. BCE Mobile offered $9.75 per share for controlling interest of MDI. Motorola's bid of $13.50 per share was ultimately accepted by MDI.[46] Clearly, the bidding process in this case earned a substantial premium for MDI's shareholders. Moreover, it arguably resulted in important potential economies, since Motorola is a world leader in products such as cellular telephones and pagers that share a common technology with MDI's products. From the perspective of MDI and industry analysts, Motorola's marketing and financial muscle were seen as enabling MDI to expand into a broader market.

Indeed, the early experience with the acquisition supports the existence of important technical and marketing complementarities. For example, MDI incorporated Motorola's transit technology into the voice and data communications system the former is supplying to B.C. Transit Corporation for the Greater Vancouver bus fleet. MDI had no previous experience in the mass transit market.[47] It is also reported that MDI's sales roughly doubled in the year following the Motorola acquisition.[48] At least part of the spurt in worldwide sales is attributed by MDI to its relationship with Motorola. In short, the Motorola acquisition of MDI appears to be providing the synergies that were anticipated by both parties.

CONNAUGHT BIOSCIENCES

THIS REPRESENTS ANOTHER highly controversial foreign acquisition. Connaught BioSciences markets insulin, sells diagnostic products and is a major supplier of vaccines. Its predecessor was CDC Life Sciences whose largest owner was the federal government's crown corporation, Canada Development Corporation.

Connaught BioSciences has an illustrious history dating to the pioneering production of insulin after its discovery by University of Toronto researchers Frederick Banting and Charles Best. It had also developed a method of mass-producing penicillin in the early 1940s and played a major role in developing and producing polio vaccines in the 1950s. At the time of its purchase by Merieux of France in December 1989, Connaught's largest single shareholder was the Quebec Pension Plan fund with a 19.3 percent stake. The next largest shareholder was Merieux itself with a 12.6 percent share. The rest of the shares were widely held. Both the Quebec Pension Plan and Merieux bought their shares in 1987 from Canada Development Corporation.

From July 1987 to February 1988, Connaught and Merieux apparently discussed various cooperative structures, including a merger through a share exchange.[49] By the end of February 1988, it looked as if no amicable accord would be reached and Merieux launched a hostile takeover attempt for a further 20 percent of Connaught shares. This attempt was blocked by the Toronto and Montreal stock exchanges. In the summer of 1988, talks started again at the request of Connaught, and a tentative agreement was reached on March 12, 1989. While various delays took place, a rival offer was received in September 1989 from Ciba-Geigy of Switzerland and Chiron Corporation of California. The latter bid was for $30 a share compared to the estimated original offer by Merieux of $25 a share.[50] At the end of September, Merieux came back with an offer of $37.50 per share. Ciba-Geigy/Chiron refused to increase their bid but left it "on the table" for consideration. After both offers received approval from Investment Canada, the Merieux proposal was accepted by Connaught shareholders.

The Connaught saga illustrates the wide spectrum of opinion regarding the underlying causes of foreign takeovers of Canadian high-technology companies. One is the ubiquitous claim that there are real efficiencies associated with these takeovers. Both Connaught and Merieux have strong positions in vaccines and serums, and both sets of managers expressed a view that economies of scale in both R&D and marketing were becoming much more pronounced in the industry. A merger between the two would presumably assist both to move towards minimum efficient scale faster than would otherwise be the case. The merger also promised to give Connaught ready access to European markets and Merieux increased access to North American markets.[51] On the other hand, Ontario's then Premier David Peterson raised a concern about the potential for a handful of companies dominating the drug industry.[52]

Whatever else might be said about the Connaught merger, it did not represent a bargain for Merieux. At least one market analyst considered a $40 a share cash bid for Connaught to be fair.[53] It is also reported that the Bank of France suggested that Rhone (Merieux's parent) had paid too high a premium for Connaught.[54] Other observers have also argued that Connaught's competitive position in the vaccine market was growing weak as a result of aging products, further suggesting that Connaught was no bargain for Merieux in light of the full price paid, including a set of undertakings made to Investment Canada. It is obviously too soon to evaluate the anticipated economies effected by the merger. However, there is some thought that without an effective alliance with another drug company, Connaught's survival was far from assured.

A significant aspect of the Connaught-Merieux case is that Merieux is partly owned by the French government. The concern here is that the French government may exert pressure on Connaught-Merieux to behave in ways that are inconsistent with a profit-oriented commercial enterprise. To the extent that the existing owners of Connaught were bought-out at a "fair" price, nonprofitable behaviour will penalize new shareholders. The latter might well include Canadian minority shareholders. However, the latter were aware of the risks associated with owning a "mixed" enterprise, i.e. part public/part private ownership. Presumably, this awareness was factored into their decision to become shareholders. In short, if capital markets are relatively efficient, concern about acquisition of Canadian companies by foreign governments must be rooted in some other type of market failure. I address this consideration below.

MOLI ENERGY

THIS BRITISH COLUMBIA COMPANY began life with a grand vision: to create hundreds of jobs with its proprietary battery technology. In its bid to be first, the company put more emphasis on increasing the volume of its shipments rather than dealing with a flaw in its product. When a fire broke out in a portable telephone that used Moli's batteries, a financial crisis was precipitated that ended Moli's hopes of forming the nucleus of a provincial high-technology industry. While Moli had raised about $90 million since it was founded in 1977, by the end of February 1990, it had run out of money. The company finished the year ending September 30, 1989 with a loss of $40.7 million on sales of $1.2 million.

At the time of writing, Moli's assets were in the process of being sold to a consortium of Japanese companies at a drastic discount to their book value. The province of British Columbia, as Moli's only secured creditor, will receive a royalty from any future sales made by the company. Other lenders and shareholders, including Teck Corporation and Alcan are left with nothing. The founder of Tech Corporation, Norman Keevil, founded Moli to produce the batteries which were based on technology developed at the University of British Columbia.

Moli enjoyed enormous success in raising capital in return for bringing what was hailed as the most advanced rechargeable power battery into the market. Specifically, the company raised money in private placements of shares with companies such as Teck and Alcan, and raised $25 million from the public in 1986 through a public share issue. It also received substantial financial aid from the province and the federal government in 1984-85. As recently as June 1988, Alcan invested $10 million in the company. The leader of the Japanese consortium, Mitsui, had also provided Moli with interim financing. In short, throughout most of its history, Moli had enjoyed great success in raising funds from Canadian investors. Moreover, the price paid by the Japanese consortium was judged to be fair market value for Moli's land plus its buildings and equipment.[55]

NOVA'S RUBBER DIVISION

NOVA CORPORATION ACQUIRED the rubber division of Polysar Ltd. in 1987, along with other petrochemical operations of the Sarnia-based company. In May 1990, Bayer A.G. of Germany purchased Nova's rubber division for a reported $1.48 billion. Bayer is reported to have won out over three other bids for the division, including a $1.2 billion bid from the Italian chemical giant Enimont. Once again, there is evidence of competitive bidding for the domestic assets in question. Stock market analysts appeared to judge the price fair and applauded Nova on the sale.[56]

While Nova's financial strategy called for a substantial reduction of debt over time, there is no doubt that Nova was capable of funding its rubber operations indefinitely. Some observers argue that the sale to Bayer enhanced the value of these assets to the extent that Bayer's facilities would allow the Canadian rubber division to increase sales in Europe and the Far East. Bayer operates in 70 countries and, besides rubber, produces dyes and pigments, polyurethane, coatings and other chemical products. The Nova purchase gives Bayer its first real base in the North American synthetic rubber business. Hence, there were suggested real economies in the form of marketing complementarities. Specifically, Bayer's facilities could be used by Nova to increase its sales of industrial chemicals in Europe and the Far East, at the same time that Bayer could use Nova's North American facilities.

OTHER CASES

HCR Corporation This company is a leader in one of the fastest growing sectors of Canada's computer industry. It was acquired by Santa Cruz Operation Inc. (SCO) of California in May 1990. HCR makes Unix-based software products. The American company is the world's leading vendor of Unix-based application software. Observers said it made sense for HCR to align itself with the American firm (which is partly owned by Microsoft) in order to compete more effectively. HCR's president said he made the deal because HCR was looking for a strategic partner, not an injection of capital. Under the

TABLE 4

DIAGNOSTICS

Test 1: Was there competitive bidding for the assets?

Test 2: Were expectations of Canadian investors "irrational"?

Test 3: Was there a "capital markets gap"?

Test 4: Were there potential market power gains?

Test 5: Were there potential efficiency gains?

SCO and Microsoft umbrella, HCR will have international distribution and marketing clout that it does not possess by itself.[57] At the same time, SCO will gain an active presence in the Canadian market. The financial terms of the deal were not disclosed.

Novatel This company is North America's leading maker of cellular telephones. It was formed in 1983 as a joint venture between Alberta Government Telephone and Nova Corporation. In August, 1990, the West German automobile electronics giant Robert Bosch agreed to pay about $100 million to buy half of Novatel. As part of the deal, Bosch was expected to move its cellular telephone operation from Berlin to Novatel's headquarters in Calgary. Bosch was allegedly looking at Novatel to serve as a base for an international thrust into cellular telephones, which Bosch sees as a natural outgrowth of its automotive operations. Novatel was seeking to take advantage of Bosch's global marketing and distribution channels. In particular, the Bosch name was seen as providing quality assurance to long-time customers such as BMW and Daimler-Benz.[58] Novatel was also said to be looking for managerial assistance from Bosch to manage its rapid growth in overseas markets. Indeed, Bosch apparently transferred a number of its executives to Novatel's headquarters.[59] However, subsequent to these developments, Novatel announced large financial losses and Bosch withdrew its bid.

As with the case for mergers and acquisitions in general, while it is difficult to categorize the likely causes and consequences of foreign acquisition of Canadian high-technology companies, the various case studies point to several conclusions which are summarized in Table 4 and Table 5. Specifically, Table 4 notes the various factors that might be considered in evaluating a proposal from the standpoint of whether active government intervention is likely to improve the wealth of Canadians. Table 5 applies these criteria to the above-cited cases.

One general conclusion that can be drawn from the examination of these foreign acquisitions of Canadian high-technology companies is that the relevant acquisitions were usually characterized by some degree of competitive bidding for the domestic assets. As noted above, if there is competitive bidding for the domestic assets, their prices will tend to be bid up to the highest reservation price of the potential buyers. In this case, efforts by Investment Canada to extract

TABLE 5

APPLICATIONS OF DIAGNOSTICS

	1	2	3	4	5
de Havilland	+	-	-	-	+
Mitel	?	-	-	-	+
Leigh	+	-	+	-	+
Lumonics	-	?	+	+	+
MDI	+	?	+	-	+
Connaught	+	-	-	+	+
Moli Energy	?	-	-	-	-
Nova's Rubber Division	+	-	-	+	+

LEGEND
+ affirms existence of diagnostic
- refutes existence of diagnostic
? inconclusive

undertakings will either promote decreases in the financial value of other elements of the bid or result in the bid being terminated.[60] Yet another possibility is that some undertakings will be made with the acquirer discounting the probability of having to follow through on its undertakings. If the undertakings are unrealistic in light of the financial circumstances of the acquisition, the acquirer may expect to be able to demonstrate at some point that implementing the undertakings will lead to financial hardship and thereby be relieved of the obligations.

Another observation is that many of the acquisitions are undertaken with the expectation of real efficiency gains being achieved or other competitive advantages being conferred on the firm being acquired. To the extent that significant improvements in the competitive position of domestic firms often result from changes in ownership, discouraging foreign acquisitions may jeopardize the growth and even the survival of domestically based companies. This represents a further caution against using a review process to extract undertakings.

While there is no support for the hypothesis that Canadian investors systematically undervalue domestic assets, there is some support for the position that selling equity to foreigners is often a cheaper source of financing than raising equity in domestic capital markets. However, this is not necessarily proof of a capital market failure in the traditional sense. The foreign investor is usually a multinational company that can bring access to foreign markets as well as financial capital. Equity ownership in these cases is a way of cementing a strategic alliance that promises to improve the competitive position of both companies.

It is impossible to determine whether and to what extent Investment Canada is able to leverage higher effective prices for domestic assets through the review process. There is, however, a potential argument for extracting certain undertakings from the acquirer where the social benefits of the undertakings exceed the social costs, including the risk of a lower bid price or even a retraction of the bid. At the same time, the expected social value of the domestic assets operated by a Canadian-owned company may exceed the private value of those assets to the domestic owner. While it may pay the domestic owner to sell out to a foreigner at a certain price, the price paid (even if equal to $E(V)_f$ may be less than the expected social value of the assets in Canadian hands. This might be the case, for example, if there are strong external economies when the assets are owned by Canadians rather than foreigners.

In the literature, the primary source of these potential external economies is domestic R&D expenditure. Critics of foreign acquisitions of Canadian firms point to the likely centralization of R&D expenditures in the parent company as a major negative result of the acquisitions.[61] There could be social costs to this centralization to the extent that domestic R&D activities create spillover opportunities for other domestically based firms.

In this context, it may be argued that efforts by Investment Canada to encourage (implicitly or explicitly) foreign acquirers to undertake more domestic R&D, or at least to maintain current domestic R&D levels, might improve social welfare even if those efforts result in a lower acquisition price paid to domestic shareholders. Equally, social welfare might be improved by Investment Canada if it favoured the bid of one would-be acquirer over another (even though the latter offered a higher price to domestic shareholders) because the former was committed to doing more domestic R&D.

Note that when increased R&D is encouraged at the cost of a lower price bid to domestic shareholders, there are domestic distributional consequences that do not arise when economic rent is transferred from foreign shareholders to any group of Canadians. Hence, we are considering the potential for domestic welfare strictly in a benefit-cost sense and not in the sense of a Pareto-efficient improvement.

RESEARCH AND DEVELOPMENT SPILLOVERS AND INVESTMENT CANADA UNDERTAKINGS

A REVIEW OF THE AVAILABLE INFORMATION suggests that research and development undertakings are of prominent concern in those high-technology acquisitions that are eligible for review. Specifically, in a number of the case studies cited commitments to fund domestic research and development are an identifiable feature of the approval process involving Investment Canada and/or the relevant governments (provincial or federal). For example, Mitsui and its partners agreed to invest a minimum of $10 million for R&D and to correct a defect in Moli's proprietary battery technology. They will have three years to establish a local plant as a commercially viable operation. The consortium has also agreed to keep future research and all manufacturing in the province for at least five years.[62]

In the case of de Havilland, the firm was assured a world product mandate to protect its operations in Canada. Boeing also expressed its intentions to commit hundreds of millions of dollars to develop de Havilland products and improve the latter's facilities.[63] A 1986 memo of understanding included protection of de Havilland's patents and processes, production in Canada, upgrading R&D and providing for Canadian equity participation.[64]

As part of the takeover of Nova's rubber division, Bayer committed itself to maintaining and possibly expanding the North American rubber research and development facilities at Polysar's Sarnia research centre. Similarly, it is reported that under an agreement with Investment Canada, Merieux agreed to make a significant increase in R&D spending at Connaught and, within 18 months, to float up to 50 percent of the company's shares to the Canadian public. Indeed, Connaught announced after the agreement with Merieux that it will launch a $29-million five-year vaccine research program.[65]

In evaluating the commitments extracted from foreign acquirers, several issues are relevant. One, as noted above, is whether the undertakings are likely to come at the expense of other components of the acquirer's overall purchase price. If they do, there is simply a substitution of one type of expenditure for another. Whether there is a net welfare improvement depends upon many factors. The emphasis on encouraging R&D expenditures is predicated on the view that R&D spillovers are large and that foreign owners will "underinvest" in domestic R&D. However, to the extent that other factors of production are less generously rewarded than they would otherwise be, there could be reductions in the growth of complementary factors such as indigenous entrepreneurs. For example, reductions in the returns that original shareholders can expect to receive from foreign acquisitions will, on the margin, discourage Canadian entrepreneurs from setting up domestically based high-technology companies.

A second consideration is that requiring undertakings on the part of foreigners creates a risk of the takeover failing to materialize or of lengthy delays in the completion of a deal. That is, a misjudgment of the rents available to foreigners could lead to government negotiators attempting to extract too high a price from would-be acquirers. In this case, the foregone benefits of uncompleted foreign acquisitions must be set against the social benefits of encouraging greater expenditures on activities with relatively large spillover benefits.

In this context, the risks of allowing foreign investors carte blanche to acquire domestically owned companies are associated with presumed foregone R&D externalities. It is useful, therefore, to consider more formally the relationship between foreign acquisitions and R&D externalities.

R&D PERFORMANCE AND FOREIGN TAKEOVERS

CONSIDER THE FOLLOWING STYLIZED EXAMPLE. Imagine foreign company F is planning to acquire domestic company D. The R&D capital stock of D has a current value of R_1. If the relevant assets remain under D's ownership, the R&D capital stock is expected to increase over time at a rate of g per period. If the assets are transferred to F, the R&D capital stock will increase by h per period. The spillover benefits to the domestic economy from a unit increase in D's R&D capital stock are assumed equal to S_d. The spillover benefits to Canada from a unit increase in the R&D capital stock when under F's control are assumed equal to S_f.

The future stream of spillover benefits from continued domestic ownership (DB) is therefore:

$$DB_t = R_1 (1+g)^t S_d$$

The future stream of spillover benefits associated with a foreign takeover $(FB)_t$ is:

$$FB_t = R_1 (1+h)^t S_f$$

Hence, DB_t will exceed FB_t to the extent that g exceeds h and S_d exceeds S_f.

The conventional wisdom reflected in Canadian science policy literature is that economies of scale in the R&D activity will encourage foreign-owned multinationals to centralize R&D in the home country affiliate. This hypothesis is supported by evidence that foreign-owned firms in Canada are generally less research-intensive than their domestically owned counterparts.[66] To be sure, econometric identification of the ownership-R&D performance relationship is plagued with difficulties, and exceptions to this interpretation can be found for specific industries.[67] Moreover, conventional R&D measures ignore the substantial amount of technology that is transferred from the parent company to its foreign subsidiaries, which is not conventionally identified as R&D. Presumably, these transfers contribute to the growth in the Canadian firm's R&D capital stock and can be a further source of spillovers to the domestic economy.[68] Nevertheless, if there is a propensity for multinational companies to agglomerate R&D at corporate headquarters, this consitutues a potentially significant external *diseconomy* associated with foreign takeovers of domestic companies.

It does not necessarily follow that propensities of multinationals to centralize R&D at home will result in less R&D being undertaken by acquired Canadian companies; i.e. that h will be less than g. For example, in the extreme, a domestically owned company might be on the verge of bankruptcy. In the absence of a foreign takeover, g might reasonably be expected to go to zero.

Generally, the accumulation of R&D capital in the Canadian company is expected to be a function of the anticipated rate of return to accumulating R&D capital in Canada. Foreign-owned firms may have higher opportunity costs to do R&D in Canada; however, they also own complementary assets that could contribute to realizing higher returns on a Canadian R&D capital stock.[69] Hence, it is quite possible that h will ordinarily be greater than g. At the least, the issue is an empirical one.

Unfortunately, there is very little available evidence on the impact of foreign takeovers of domestic companies on the R&D performances of the acquired companies. One broad survey of the performances of Canadian- and foreign-controlled manufacturers in Canada suggests that foreign takeovers of domestically owned R&D-oriented firms have mixed results on R&D performance. Specifically, "very" R&D-oriented firms become even more R&D-intensive post acquisition. However, where R&D intensity is the ratio of R&D expenditure to total revenue,[70] small and medium firms trended downward in their R&D intensity. All other things the same, this suggests that the impact of foreign acquisitions on domestic R&D expenditures depends upon the nature of the firm acquired. Paradoxically, it appears that foreign acquisitions of large, domestically owned R&D-intensive firms generate less concern about a reduced growth in R&D activity than do acquisitions of small domestically owned firms.

One complicating intervening factor is the impact of foreign takeovers on the growth of domestic companies. For example, if a foreign takeover results in a slower growth in the acquired firm's revenues than would otherwise be the case, total R&D expenditures might fall even if R&D intensity is increased. In this regard, Canadian firms that moved to foreign control had close to average growth rates in sales revenue.[71] Hence, the influence of foreign takeovers on domestic R&D performance appears not to be conditioned by slowdowns in the growth rates of the acquired companies. In short, this survey by itself does not support a conclusion that foreign takeovers of prominent domestically owned high-technology companies will encourage reductions in the rate of growth of the domestic stock of R&D capital.

A comprehensive statistical study of a sample of U.S. companies concluded recently that there is very little evidence that acquisitions cause a reduction in R&D spending.[72] However, that study does not separately identify the effects of foreign acquisitions and domestic acquisitions. Indeed, it concludes that foreign firms tended to acquire domestic companies with significantly below average R&D intensities and, hence, that foreign acquisitions could not be playing a large role in terms of influencing overall R&D expenditures in the United States.[73] This is not the equivalent concern of this paper; i.e. how is the R&D performance of an acquired company affected by foreign ownership?

Several simple comparisons of R&D expenditures before and after a foreign acquisition are possible. For example, Table 6 reports R&D expenditures for Mitel and de Havilland. Mitel was acquired by British Telecom in May 1985. The data reported in Table 6 are nominal R&D expenditures. For the period 1983 - 85, Mitel's R&D spending averaged approximately $36.8 million.[74] Over the period 1986 - 89, Mitel's R&D spending averaged about $36.4 million. Corresponding estimates for de Havilland are $59.1 million and $68.4 million respectively. Thus, in nominal terms at least, foreign takeovers of these two high-technology companies left total R&D spending either unchanged or higher than it was pre-acquisition.

TABLE 6
R&D SPENDING BY YEAR
($ MILLIONS)

YEAR	MITEL	DE HAVILLAND
1983	$27.1	$87.6
1984	49.5	49.7
1985	33.9	39.9
1986	37.0	56.9[1]
1987	53.3	42.7
1988	26.4	83.0
1989	29.0	91.0

[1] From 1986, R & D expenditures are for Boeing of Canada. It is likely that most are related to de Havilland's activities.

SOURCE: Annual Reports and various issues of the *Financial Post*

Obviously a comparison of R&D expenditures in real terms is more desirable. Unfortunately, no R&D expenditure price index is available. However, other authors have used a price index for machinery and equipment as a proxy. Over the period 1983 - 85, this price index for Canada averaged 93.6, with 1986 equal to 100. The index averaged 97.6 over the period 1986 - 89. It might therefore be concluded that there was a slight decline in real R&D expenditures for Mitel in the post-1985 period. However, after adjusting for the increase in the price index, R&D expenditures in the post-1985 period are higher than in the pre-1985 period for de Havilland. On balance, there is no evidence to suggest that foreign acquisitions reduce real R&D expenditures in Canada.

R&D SPILLOVERS AND FOREIGN ACQUISITIONS

TO THE EXTENT THAT A DOLLAR SPENT on R&D by a domestically owned firm imparts greater spillovers than a dollar spent by a foreign affiliate, the total economic benefits of R&D carried out in the former will exceed those of R&D carried out in the latter, holding total R&D expenditures constant.

It has been convincingly demonstrated that positive and significant spillovers derive from domestic R&D expenditures. That is, social rates of return to R&D exceed private rates of return.[75] Unfortunately, it is not possible to determine the spillovers created by affiliates' R&D activities relative to those created by domestically owned firms in the same industry. A conventional view among some science policymakers is that since the R&D carried out by domestically owned firms has a higher share of basic and applied research, the spillovers created by domestically owned firms' R&D are greater than those associated with affiliates' R&D expenditures. Of course, it might be argued that most of the spillover benefits from basic research carried out in Canada are captured by firms outside Canada. Cost reductions, which derive from using improved inputs and the like, presumably stem primarily from development efforts.

Some insight into the relationship between R&D performance and R&D spillovers is provided by Bernstein's inter-industry spillover network for nine Canadian industries. Four of the nine industries are affiliate-intensive. The average social rate of return to R&D expenditures for these four industries is virtually identical to the average social rate of return to R&D for the other five industries.[76] In short, what sketchy evidence is available suggests that spillovers per dollar of R&D may not differ significantly between foreign- and domestically owned firms.

Finally, it may be concluded that, on balance, neither overall R&D nor spillovers-per-dollar of R&D is affected by foreign takeovers of technology-intensive companies. Indeed, given evidence that foreign affiliates are better able to exploit R&D spillovers than their domestically owned counterparts, overall rates of technological change may actually accelerate through such takeovers.

SUMMARY AND CONCLUSIONS

THIS STUDY IS ESSENTIALLY CONCERNED with potential economic justification for government intervention in foreign takeovers of Canadian high-technology companies. It argues that intervention is potentially justified if larger payments to Canadians can be directly or indirectly extracted from acquiring companies and/or if specific takeovers have social costs that exceed social benefits, notwithstanding the willingness of the acquired firm to sell out.

The paper essentially concludes that the market for such acquisitions is competitive and, therefore, that foreigners will ordinarily pay up to their reservation prices for domestic assets. Investment Canada can therefore (through the review process) affect the nature of the overall purchase price, but not the final price paid. The influence can be registered either through requiring explicit undertakings or (more efficiently) by encouraging foreign acquirers to adhere to business plans that are likely to maximize the social benefits of the acquisition.

Given the existence of spillovers to R&D-related activities, there is a potential social welfare argument for Investment Canada implicitly or explicitly encouraging acquirers to eschew R&D reductions as part of their business plans. In this context, domestic acquired firms may receive a lower bid price; however, to the extent that acquired firms received government grants that helped add value to their assets, some payoff to Canadians would seem appropriate.

In short, there is a theoretical welfare improving role for Investment Canada to play in reviewing foreign acquisitions. It effectively involves transforming rents that would be received by domestic acquired firms into R&D (and related) expenditures by foreign-owned firms; however, this role is circumscribed by the risk that Canadian entrepreneurship may be discouraged if it is perceived that rates of return to venture capital investment are declining as a result of Investment Canada policies.

It might be concluded that Investment Canada has adopted a reasonable posture toward foreign acquisitions in that it has not sought to block foreign acquisitions. Nor has it sought to leverage higher effective prices from would-be foreign acquirers. Rather, it has seemingly sought to ensure that an "appropriate" mix of payoffs is realized by Canadians without discouraging ownership transfers from domestic to foreign investors. From a normative perspective, this is a potentially reasonable, albeit difficult, public policy activity. Indeed, to the extent that the favourable R&D performance of acquired firms reflects Investment Canada's influence, it is arguably a measure of the success of the review process. What is clearly not called for, given the available evidence, is an adversarial stance toward foreign acquisition of domestically owned technology-intensive companies.

ENDNOTES

1. For some indirect evidence on the cyclical nature of public policy toward foreign direct investment, see Steven Globerman, "The Consistency of Canada's Foreign Investment Review Process: A Temporal Analysis", *Journal of International Business Studies*, Spring/Summer 1984, pp. 119-129.
2. For a discussion of the relevant changes under the *Investment Canada Act*, see Investment Canada, *Annual Report 1985- 86*, Ottawa, Minister of Supply and Services Canada, 1986, and Investment Canada "Experience With The Review Function of Investment Canada", Ottawa, mimeo, undated.
3. The review process may have indirect consequences for capital flows that are not identified by the approval rate. For a discussion of the issues involved in identifying the influence of the review process on inward direct investment, see Steven Globerman, "Canada's Foreign Investment Review Agency and the Direct Investment Process in Canada", *Canadian Public Administration*, Fall 1984, pp. 313-328.
4. See James Gillies, "Industrial Strategy Vital To Canada Becoming a Developed Nation", *The Globe and Mail*, June 2, 1990, B2.
5. For early statements of this argument, see Science Council of Canada, *Innovation in a Cold Climate*, Report Number 15, Ottawa, Information Canada, 1971 and Arthur Cordell, *The Multinational Firm, Direct Foreign Investment and Canadian Science Policy*, Ottawa, Information Canada, 1971.
6. See Diane Francis, "Taxpayers Cheated in Leigh Selloff", *The Financial Post*, July 18, 1990, p.3.
7. For relevant discussions of the shortcomings, see Kristian Palda, *Industrial Policies Toward Innovation*, Vancouver, The Fraser Institute, 1984.
8. There is an extensive literature dealing with these issues. For early, seminal studies see Jacob Schmookler, *Invention and Economic Growth*, Cambridge, MA, Harvard University Press, 1966 and C.T. Taylor and Z.A. Silberston, *The Economic Impact of the Patent System*, Cambridge, Cambridge University Press, 1973.

9. This is not to minimize the fact that in individual samples of firms or industries, there may be a relatively low correlation between patenting and R&D activity.
10. There were 103 reported acquisitions in 1985.
11. See Richard Roll, "Empirical Evidence on Takeover Activity and Shareholder Wealth" in John C. Coffee Jr., Louis Lowenstein and Susan Rose-Ackerman, *Knights, Raiders and Targets*, Oxford, Oxford University Press, 1988, pp. 241-252.
12. B. Espen Eckbo. "FIRA and the Profitability of Foreign Acquisitions in Canada", University of British Columbia, mimeo, 1986.
13. See Karen Benzing. "Merieux Cuts Deal with U. of T." *The Financial Post*, October 26, 1989. It should be noted that in only a relatively small number of "high profile" cases has Investment Canada negotiated legally binding commitments from foreign investors beyond those reflected in the investor's business plan; however, those are precisely the types of cases considered in this study. In other cases, as noted above, investors may have incorporated undertakings in their business plans in anticipation of the Investment Canada review process.
14. A version of this argument is that venture capital is relatively scarce in Canada, which rations domestic high-technology companies out of the capital markets; while venture capitalists in the United States tend to restrict their investments to U. S.-based companies.
15. Roll, "Empirical Evidence" interprets the empirical evidence as suggesting that the market for information about corporate acquisitions is relatively efficient.
16. Eckbo, "FIRA" concludes that competition among bidder firms transferred most (or all) of the acquisitions gains from foreign bidders to their respective Canadian targets over the period 1964 - 83. I again stress that Investment Canada does not see itself as playing a rent-capture role in its review process. However, under certain conditions, the effects of its actions may be to capture rent from foreign investors. In this section I am considering the potential for this to happen, as well as the consequences of imposing undertakings when rent is available for capture.
17. Roll, "Empirical Evidence" concludes that there is no support for monopoly as a takeover motive more generally.
18. See, for example, Yvon Gasse, "Attitudes Toward External Financing: A Comparison of Canadian Entrepreneurs and Owner-Managers." in Gerald d'Amboise, Yvon Gasse and Rob Dainow, *The Smaller, Independent Manufacturer: 12 Quebec Case Studies*, Montreal, mimeo, 1986.
19. See Geoffrey Rowan. "Alias Planning to Offer Shares on NASDAQ", *The Globe and Mail*, May 26, 1990.
20. For a more general discussion calling into question the relevance of capital market segmentation as a motive for foreign direct investment, see Edward M. Graham and Paul R. Krugman, *Foreign Direct Investment in the United States*, Washington, Institute For International Economics, 1989, pp. 37-39.

21. Several researchers have suggested that multinational companies may have an "uneconomic" preference for controlling interests in overseas assets, when "strategic partnerships" may be a more efficient organizational structure for international activities. See, for example, David Teece, "Strategic Alliances and Technology", University of California, Working Paper 100, 1990. It is beyond the scope of this paper to assess this suggestion critically. I merely note that strategic partnering makes more sense when the firms involved are multi-divisional and when the synergies are restricted to relatively small subsets of the firms' activities. The domestic firms acquired in takeovers tend to be specialized in fairly narrow product markets.
22. In his contribution to this volume, Teece also argues that the foreign investor brings engineering talent, manufacturing expertise and access to foreign markets to join with the domestic firm's technological expertise. However, he suggests that foreign investors are more "patient" than domestic investors who could supply similar complementary assets. He goes on to conclude that this patience allows Japanese investors in particular to benefit disproportionately from domestic technology. No direct evidence is provided in support of this thesis.
23. It is reported that Japanese foreign direct investment is increasingly filling the gap left by a "drying up" of investment funds for Initial Public Offerings. See Larry Walker, "Overseas Money Is Starting To Fill The Financing Gap", *Electronics*, August 1989, pp.43-44. Preventing foreign acquisitions may also discourage start-ups by reducing the *ex ante* returns to domestic start-ups.
24. For an overview of this evidence, see Steven Globerman, *Mergers and Acquisitions in Canada*, Ottawa, Minister of Supply and Services, 1977.
25. See Keith Cowling, Paul Stoneman, John Cubbin, John Cable, Graham Hall, Simon Domberger and Patricia Dutton, *Mergers and Economic Performance*, London, Cambridge University Press, 1980.
26. John R. Baldwin and Paul K. Gorecki, *Mergers and the Competitive Process*, Statistics Canada, Research Paper Series No. 23E, Ottawa, mimeo, 1990.
27. Christopher Waddell, "De Havilland deal won't be contested by panel, MP says", *The Globe and Mail*, January 13, 1986.
28. See Christopher Waddell, "De Havilland sale a political gamble", *The Globe and Mail*, December 7, 1985.
29. Ibid.
30. See Jennifer Lewington and Cecil Foster, "De Havilland set to be sold", *The Financial Post*, July 21-23, 1990, p.1.
31. Christopher Waddell, "De Havilland sale threatens development, union chief says", *The Globe and Mail*, January 23, 1986.
32. One of this paper's discussants, Garfield Emerson, suggested that undertakings extracted by the government are not always implemented.
33. See Lawrence Surtees, "Mitel at the crossroads: Management is out to prove skeptics wrong", *The Globe and Mail*, March 16, 1990, B11.

34. Ibid.
35. See Mike Urlocker, "Leigh Chairman Shepherd unbowed by bankruptcy", *The Financial Post*, April 23, 1990, p.2.
36. Ibid.
37. Ibid.
38. See Geoffrey Rowan, "Leigh to be sold to Quebec firm", *The Globe and Mail*, July 6, 1990, B4.
39. See Urlocker, op cit.
40. James Bagnall and Richard Siklos, "Small is expendable", *Financial Times of Canada*, April 23, 1990.
41. Charles Davies, "The Crash At Leigh", *Canadian Business*, July 4, 1990, pp. 28-34.
42. Karen Benzing, "Bid by Japan's Sumitomo offers Lumonics support in laser wars", *The Financial Post*, March 28, 1989, p.8.
43. Ibid.
44. Geoffrey Rowan, "Sumitomo unit offers to buy Lumonics Inc.", *The Globe and Mail*, March 26, 1989, B1-2.
45. "Lumonics signs Sumitomo deal", *The Financial Post*, April 8, 1988, p.22.
46. David Smith, "Richmond firm wins contracts worth $9 million", *The Vancouver Sun*, April 14, 1989.
47. David Smith, "MDI rides high after takeover battle", *The Vancouver Sun*, June 2, 1989.
48. Ibid.
49. See Margot Gibb-Clark, "Merieux found the courting of Connaught was tedious but worth-while", *The Globe and Mail*, February 20, 1990, B.19-20.
50. Karen Benzing, "New Connaught bid hits $943.5 million", *The Financial Post*, September 26, 1989, p.1.
51. See Matthew Horsman, "Globalization of drugs industry extends to Canada", *The Financial Post*, September 18, 1989, p.3.
52. See Terence Corcoran, "Peterson's unease about Connaught doesn't enlighten us much", *The Globe and Mail*, October 23, 1989, B23.
53. See Karen Benzing, "New Connaught bid hits $943.5 million", *The Financial Post*, September 26, 1989, p.1.
54. See Edward Greenspon, "Rhone won't hasten Connaught stock sale", *The Globe and Mail*, February 22, 1990, B.9.
55. Karen Howlett, "Investors and Ottawa left out in the cold as B.C. sells Moli's assets", *The Globe and Mail*, March 10, 1990, B4.
56. "Sarnia rubber plant jobs safe after Nova sale: Bayer official", *The Globe and Mail*, May 24, 1990, B8.
57. See Geoffrey Rowan, "Toronto technology firm HCR to be acquired by U.S. company", *The Globe and Mail*, May 10, 1990, B7.
58. See Edward Greenspon and Christopher Donville, "AGT may sell half of Novatel", *The Globe and Mail*, July 19, 1990, B1.

59. See Christopher Donville, "Novatel asks Bosch for help", *The Globe and Mail*, August 1, 1990, B3.
60. Several readers of this paper suggested the qualification that arbitrageurs may reap the major share of any increases in the prices of acquired Canadian companies. Even if true, it is not clear that this is a relevant qualification. For one thing, the arbitrageurs may be Canadians. For another, if the arbitrageurs earn no more than a competitive rate-of-return for absorbing risk that original Canadian shareholders prefer not to bear, the latter can still be said to have captured the available takeover "rents", at least in a risk-adjusted sense. Once again, one's view of the efficiency of capital markets is important. It should also be noted that in most of the cases discussed above, Investment Canada imposed no explicit undertakings on the acquirer. Rather, undertakings were incorporated into the business plan of the acquirer. The voluntary undertakings may well have reflected a perception of what Investment Canada was looking for in the business plans submitted. In any case, Investment Canada did not attempt to extract any additional rent through explicit negotiation.
61. See, for example, Bernard Bonin, "The Multinational Firm as a Vehicle for the International Transmission of Technology", in Gilles Paquet, ed., *The Multinational Firm and the Nation States*, Don Mills, Collier-Macmillan Canada, 1972, pp. 111 - 126.
62. See Karen Howlett, op. cit. Note that in this case, the provincial and federal governments negotiated with Mitsui.
63. See Christopher Waddell, January 23, 1986, op.cit.
64. See Alain Toulin and Peter Morton, "Ottawa to pin Boeing commitments on buyer", *The Financial Post*, July 23, 1990, p.5. Again, the federal government was directly the negotiator of these commitments; however, the principles about rent capture are the same as would apply if Investment Canada had been the negotiator.
65. Geoffrey Scotton, "No buyers for Connaught issue", *The Globe and Mail*, July 19, 1990, p.13.
66. Surveys of relevant evidence can be found in Gary K. Hewitt, "Research and Development Performed in Canada by American Manufacturing Multinationals", in Alan M. Rugman, ed., *Multinationals and Technology Transfer: The Canadian Experience*, New York, Praeger Publishers, 1983, pp. 36-49, and Guy Steed, *Threshold Firms: Backing Canada's Winners*, Ottawa, Science Council of Canada, Background Study 48, July 1982.
67. See Judith A. Alexander, "The Determinants of Research and Development Activity in Domestic and Foreign Controlled Industries" in Alan M. Rugman, ed., op. cit., pp. 26-35 and the studies cited therein.
68. See Richard Caves, *Multinational Enterprise and Economic Analysis*, Cambridge, Cambridge University Press, 1982.
69. These complementary assets include marketing channels, manufacturing expertise and so forth.

70. See Regional Data Corporation, *Performance of Canadian and Foreign-Controlled Manufacturers in Canada, 1985 - 87*, Report to Investment Canada, Ottawa, mimeo, 1990.
71. Ibid.
72. Bronwyn H. Hall, "The Effect of Takeover Activity on Corporate Research and Development", in Alan J. Auerbach, ed., *Corporate Takeovers: Causes and Consequences*, Chicago, The University of Chicago Press, 1988, pp. 69-100.
73. It is also true for Canada that high-technology acquisitions are a relatively small share of all acquisitions.
74. The assumption here is that Mitel's 1985 R&D budget was set before the acquisition by British Telecom.
75. A number of studies are cited in Jeffrey Bernstein, "R&D Capital, Spillovers and Foreign Affiliates in Canada", this volume.
76. Ibid, Table 4.

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DISCUSSANT'S COMMENT

DISCUSSANT
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LET ME BEGIN WITH TWO COMMENTS on issues of definition. The first is whether a company which is clearly not high-tech can become high-tech. In other words, how should one define high-tech, and what is it, precisely, that distinguishes a high-tech operation from any other operation? It is difficult for Investment Canada to come to terms with this sort of problem. Consider, for example, Consumers Gas, which is virtually non-tech, but has been taken over by British Gas, which is a significant technology-oriented company. Does the fact of its takeover immediately make Consumers Gas a high-tech company, or is something more required? Consider too, that the markets for gas in North America are becoming commoditized and that this is triggering a whole new set of changes with the end-result that the gas industry can no longer be regarded as mature. Also, for environmental and other reasons, technology may be applied at the distribution end, rather than by the customer. Should considerations such as these be taken into account in defining high-tech activity?

The second definitional issue is, what do we mean by mergers and acquisitions? Canadians have had minority interests in any number of local affiliates of foreign companies, such as C.I.L. and Celanese. This practice will not continue to work in a globalizing world. For reasons of tax and cost of production, foreign parents now want to take out the Canadian minority and worry about product mandates and R&D later. This makes it difficult for Investment Canada to negotiate these issues up front.

Turning to Professor Globerman's analysis, I suggest that as far as the valuation gap issue is concerned, the majority of foreign investors will pay very close to their reserve price for globalizing reasons, even where they have an advantage over domestic purchasers and even though Investment Canada may wish to negotiate side agreements around R&D. The reasons are that the Free Trade Agreement provides a superior degree of access to the United States market vis-à-vis other trading blocs, and that financial capital is chasing human capital. I suspect that the foreign acquirer is quite happy to pay the reserve price. Having intended to use the human capital in any event, it is merely a "gimme" for Investment Canada.

With respect to the scarcity of investment capital in Canada, there is no shortage of Canadian venture capital. In fact, most observers would say there is a surplus of Canadian venture capital and venture capital pools. These pools are closely linked with venture capital pools and other types of syndicating arrangements in the United States for two reasons. First, the Canadian pools need outlets in the United States because they feel they cannot find enough opportunities in Canada. Second, they act as a window on Canada for the American pools. What this does is set the investment standards on a North American basis, not just on the Canadian basis, both for product potential and, more importantly (a consideration which everybody seems to overlook) for the business acumen to implement the product potential. The links between the Canadian and American venture capital pools guarantee a supply of venture capital, provided the standards are met. The griping comes from the demand side — which suggests to me that the nub of the problem has to do with meeting standards. The problem is not a shortage of good ideas; rather, it is a shortage of people with the willingness or business acumen to implement the good ideas.

When one moves to the second stage in a firm's development (when it may go public, market conditions permitting) there is no evidence to indicate that public markets have not been prepared to provide follow-up funds. Of course there have always been conditions to secure such funds. First, Canadian venture capitalists and their partners in the U.S. should maintain their imprimateur by staying in to some extent. Second, the venture capital area is technically complex and specialized. Broad capital markets are not capable of dealing with it and have no interest in coming in unless professional providers of venture capital have been involved in the initial stage. What happens so often in Canada for example, is that, because of the business acumen problem, governments replace professional venture capitalists at stage one. Capital markets are not stupid. They know that if you skip the stage one process and the government intervenes, you probably have a disaster on your hands.

These are the kinds of things that account for the perception gaps but not the reality of gaps. In fact, the evidence suggests that there has been a plentiful supply of capital in the public markets at stage two.

The stage three problem begins when the company must secure the critical mass and economies of scale on an international basis. That is not a capital markets issue; it is a strategic linkage issue. If a Canadian inventor has created a widget that has constructive superiority (which means it will move faster on the learning curve than comparable products in the world) the New York Stock Exchange will provide the money. Given Canada's percentage of world output, that type of incidence is likely to be rare. More likely, it will be a promising product that requires both business and capital market reinforcement.

As for the case studies, my suspicion is that they are situation-specific and I do not believe that generalizations can be derived from them. With respect to the acquisition of de Havilland by Boeing, I conclude that it is probable that the transaction represented a transfer of wealth from Boeing to both the Canadian taxpayer and to specific suppliers of factors of production.

In the case of Mitel, it should be noted that Mitel's financial problems were business problems, not capital market problems. Mitel needed both deep pockets and a strategically placed partner. British Telecom had deep pockets but it had no expertise to bring to bear. From the point of view of domestic social welfare (assuming, as I believe, that the company was faltering) it was a win-win situation for Canada because the taxpayer was spared the pressure of bailing it out and the original Canadian shareholders were able to exit at a very good price. The factors of production did better for a time than they would otherwise have done.

I regard Leigh and Lumonics as stage three problems in which strategic alliances were required. The Connaught/Merieux transaction was a stage three problem aggravated by the expiry of some important cash flow patents and a shift to biotechnology work. With respect to the reserve price issue, I looked at the figures and I believe the price was at least the reserve price, if not higher.

Insofar as the purchase of the Nova/Polymar rubber division by Bayer is concerned, I believe the reserve price was met. It remains to be seen whether the complementarity of the rubber division with Bayer will prove to be an example of financial capital chasing human capital with the R&D activities prospering in Canada. I think the prospects are favourable, and I do not think there is any evidence that Investment Canada's involvement had a negative impact on this transaction.

Concluding, I would note that Investment Canada's role in negotiating R&D commitments rests on the hypothetical propositions that R&D would otherwise be centralized in the parent's home-country and that domestic R&D generates high domestic social returns. There is also the consideration that Investment Canada cannot influence a more important welfare-inducing variable — the formation of human capital — which will attract R&D to Canada in a globalizing world. Investment Canada should therefore operate at the margin of high-tech foreign takeovers, keeping in mind the potential domestic welfare trade-offs and erring on the side of flexibility and accommodation.

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10

Employee and Supplier Learning in the Canadian Automobile Industry: Implications for Competitiveness

INTRODUCTION

IN THE EARLY 1980S, North American automakers (original equipment manufacturers or OEMs), realized that their Japanese competitors were simultaneously achieving both quality improvements and lower costs. Consumers reacted to the price/performance gap and made their opinions known via the marketplace. The shrinking share of the market held by traditional North American vehicle and parts producers sparked a decade-long search for ways to improve product quality and reduce costs. This paper offers some conclusions about the overall experience, the lessons learned and the learning process itself, with particular reference to the situation in Canada.

There is now a consensus that the Japanese adopted selective technologies from Europe and North America and incorporated these into a production system designed to satisfy the demands of those markets. In the process, they succeeded in creating a sustainable competitive advantage by developing a superior way to organize and manage their production system — a system emphasizing teamwork, continuous learning, the elimination of waste, and the relentless pursuit of quality as defined by value to the customer. The system depends for its success on developing and utilizing human resources effectively, rather than on Japanese cultural traits or high technology.

There is no doubt that if the Canadian automotive industry is to be competitive, it must take heed of recent experience and learn from the production system pioneered by the Japanese — which continues to evolve as it is adopted internationally. In Canada, some change is already visible, but is the pace fast enough compared to Japan and the United States — with whom Canada shares an integrated market? How can the learning rate be accelerated? What role can foreign investment and strategic alliances play? These are some of the questions raised in the following pages as we examine two crucial aspects, labour-management and buyer-seller relations. Our analysis is based on interviews with auto and parts manufacturers, industry associations and government departments in Canada, Japan and the United States.

The first section provides some background and compares the key concepts of the North American and Japanese production systems with a view to identifying those aspects of the Japanese system that need to be learned in North America.[1] This is followed by a discussion of the Canadian experience and a description of the type of labour-management relations required to implement the Japanese system. We then turn to the question of learning in the context of North American buyer-supplier relations. Both Japanese and North American assemblers have introduced significant new sourcing practices. As a reaction to the Japanese, the North American assemblers have instituted a series of quality-rating programs and encouraged their suppliers to develop their own design and engineering capabilities. The final section assesses the implications for Canadian competitiveness.

WHAT IS TO BE UNLEARNED AND WHAT IS TO BE LEARNED?

BY MOST ACCOUNTS, the magnitude of the performance gap between the North American and Japanese manufacturers, and the nature of the changes required to reduce or eliminate it, were seriously underestimated during the 1970s and early 1980s.[2] It was particularly difficult for North Americans to believe that Japan was achieving continuous improvement in quality and productivity as a result of a new production system. It was much easier to believe their results were due to more conventional influences like lower factor costs, higher capital intensity, widespread automation and a workaholic and collectivistic Japanese culture. However, when North American automotive industry executives visited Japan, they typically returned with reports of a dynamic new approach to achieving higher quality and productivity based on systematic, organization-wide learning.

By the mid-1980s there was a small, but committed group in the industry intent on creating a North American "quality revolution", based on fundamental changes in the relationships between functional departments, between managers and engineers, between labour and management, and between assemblers and suppliers. At roughly the same time, the Japanese transplants became operational in North America and their performance confirmed that the Japanese production system could be successfully transferred.

THE NORTH AMERICAN SYSTEM OF MASS PRODUCTION

THE PHENOMENON OF MASS PRODUCTION in the automotive industry is closely identified with Henry Ford and his efforts to design a car and a production process that would satisfy the demands of a mass market.

Jobs were broken down into small steps which could be easily mastered by inexperienced workers. Since individual workers had no way to coordinate their tasks with others in the production process, the coordinating role was the responsibility of supervisors. A hierarchy of managers was therefore needed to integrate operations at each level. Each level in the hierarchy established the rules by which the next lower level in the organization would operate. Organized labour patterned itself to fit the mode of production. Thus, job categories were precisely and rigidly defined — partly to protect employees from arbitrary disciplinary action and partly to obtain a degree of job security. Rigid job classifications and work rules also created clear distinctions between the respective rights and responsibilities of labour and management. Labour was responsible for performing specific manual tasks; management was responsible for taking the initiative to identify and solve problems.

Separating the responsibility for *thinking* from the responsibility for *doing* had a profound effect on attitudes towards quality; quality became the domain of staff specialists. Mass production relied on inspection to separate bad product from good product. Defective products inadvertently shipped to the consumer were dealt with by means of product warranties that allowed a customer to return a defective product free of charge for replacement or repair. Defective products did not matter much as long as costs were relatively low and all the competitors played the game by more-or-less the same rules. For decades the North American pattern of mass production was highly successful and was therefore imitated by competitors in other countries.

The widespread adoption of this model involved considerable learning. For example Brash quotes a senior parts executive describing the contribution which General Motors made to Australian industry:

> "By forcing suppliers like ourselves to meet their specification requirements, they brought about something of a revolution in components manufacture. They encouraged association with other U.S. companies and also provided direct technical assistance. Because of this initial pressure, we have become better manufacturers and with competence in one field we have been led into other fields such as precision equipment." (Brash, 1966, p. 200)

This account of General Motors' "contribution" to its Australian suppliers sounds very much like the response of North American parts suppliers who have more recently begun to sell to the Japanese transplants.

Developments in the Canadian industry have followed those in the United States. However, with a much smaller market, high tariffs and all the American assemblers represented in Canada, productivity was considerably lower than in the United States. Beginning in 1965, the Canada-U.S. Auto Pact ushered in a full integration of Canadian and American operations. Canadian plants were managed in the same way as American plants and the same union, United Auto Workers, represented workers in both countries.

THE JAPANESE SYSTEM OF SMALL-LOT CONTINUOUS-FLOW PRODUCTION

TOYOTA IN PARTICULAR played a leading role in developing an approach which has been adopted and further refined by other Japanese producers (see Table 1). Many of the features of the Toyota production system share a common foundation in the Japanese quality movement of the 1950s.

The easiest way to characterize the Toyota production system is to cite the published accounts of two of its creators. In the preface of his book, *The Toyota Production System: Beyond Large-Scale Production*, Taiichi Ohno, a former Toyota Vice-President, descibes how the Toyota production system was developed in order to supply Japan's small, fragmented market, given Toyota's limited technological capabilities and acute shortages of investment and working capital:

> "The Toyota production system evolved out of need. Certain restrictions in the marketplace required the production of small quantities of many varieties of products under conditions of low demand, a fate the Japanese automobile industry faced in the post-war period." (Ohno, 1988, p. vii)

In a similar vein, Shigeo Shingo, who taught a generation of Toyota engineers in the 1950s and '60s, points to the necessity to eliminate all non-value-added elements from production:

> "What is the Toyota production system? When asked this question, most people (80 percent) will echo the view of the average consumer and say: 'It's a kanban system'; another 15 percent may actually know how it functions in the factory and say: 'It's a production system'; only a very few (5 percent) really understand its purpose and say: 'It's a system for the absolute elimination of waste'." (Shingo, 1989, p. 67)

The overriding priority in developing the Toyota production system was to reduce the waste in setup time needed to change from producing one type of part to another. For example, Toyota modified mass production technology to allow quick exchange of dies. This became possible when it was recognized that there are two distinct sub-processes in a die change. One part of the process, which Shingo termed internal, can proceed only when the stamping machine is stopped. The other process is external to the stamping machine, and can be performed while the machine is still operating. A systemic study of the internal and external aspects of a die change showed that, in theory, only two minutes of a die change is internal. By the mid 1960s Toyota used this knowledge to reduce set-up times from sixteen hours to just under five minutes (Shingo, 1989)!

Reduced set-up times permitted small-lot production. As a result, major changes in work organization were introduced to achieve greater flexibility. To

TABLE 1

THE TOYOTA PRODUCTION SYSTEM (TPS)

PHILOSOPHY: "GOOD THINKING MEANS GOOD PRODUCT"

Just-in-Time: The "Just-In-Time" production philosophy is the foundation of the Toyota manufacturing process. This concept refers to the manufacturing and conveyance of only what is needed, when it is needed, and in the right amounts. In addition, a minimum amount of inventory is on hand to enhance efficiency and enable quick response to change.

Jidoka: The assurance of top quality cars is maintained through "Jidoka". This defect detection system automatically or manually stops production whenever an abnormal or defective condition arises. Improvements are then made by directing attention to the stopped equipment and the worker who stopped it. The Jidoka system demonstrates faith in the worker as a thinker and allows all workers the right to stop the line. Thus, defects are not passed on to the next station, which is considered the "customer" of the previous station.

Kanban: Toyota's use of "Kanban," a unique information-carrying device, ensures that every operation produces only the amount of a product that will actually be used in the next step of the production process.

Heijunka: The "Heijunka" method of leveling production at the final assembly line makes Just-In-Time production possible. It involves averaging both the volume and sequence of different model types on a mixed-model production line.

Kaizen: "Kaizen," or continuous improvement, is the hallmark of TPS. Its primary objective is to identify and eliminate "Muda" or waste in all areas of the production process and to improve quality and safety. The key elements of Kaizen emphasize making a task simpler and easier to perform, increasing the speed and efficiency of the work process, maintaining a safe work environment, and constantly improving product quality.

Standardized Work: Standardized work sheets show the proper way to perform tasks — right down to the degree of human arm rotation. Takt Time is the amount of time required to complete a single process. If "Tatk Time" is four minutes, for example, than a completed Corolla goes out the door every four minutes.

SOURCE: Modified from Toyota Motor Manufacturing Canada Inc. document

produce in small lots, workers are organized into small teams of multi-skilled workers which are redeployed as necessary. The team concept is also the building block for quality circles in which workers use a variety of techniques to identify the root causes of production problems. This facilitates self and sequential quality inspection and continuous improvement which eliminates defects at their source. Hence, the small team concept helped Toyota achieve a competitive advantage in product quality. Work teams also prevent defective work from moving to the next stage of production — unlike mass production where quality is inspected only after all stages of production have been completed.

Producing in small lots made it possible to implement a "pull" system of production, known as a "just-in-time" or "kanban" system that allows each work team to treat the next team as its customer and produces only what the customer can immediately use. By using kanban both within and between plants, inventory was reduced throughout the entire production chain by means of just-in-time delivery.

Toyota defines quality as value to the customer. All activities and costs which do not generate such value are defined as waste which, over time, must be systematically eliminated from all production processes. By this reasoning, reducing costs and eliminating defects were simply two aspects of the same process of continuous improvement which, combined with small-lot production, had profound consequences.

Toyota established both cost and quality parity with North America by the mid 1960s, although at a much lower scale of production (Cusumano, 1988) and thereafter gradually surpassed North American levels. The Japanese had substituted a production system based primarily on the *economies of scale* with their own system based on *economies of scope*. In others words, they created a system in which many products could be produced in small quantities without a productivity disadvantage. This system has been aptly referred to as "flexible mass manufacturing" (MIT Commission on Industrial Productivity, 1989, p.19), and "lean production" (Womack, Jones and Roos, 1990). We prefer to call it small-lot continuous-flow production.

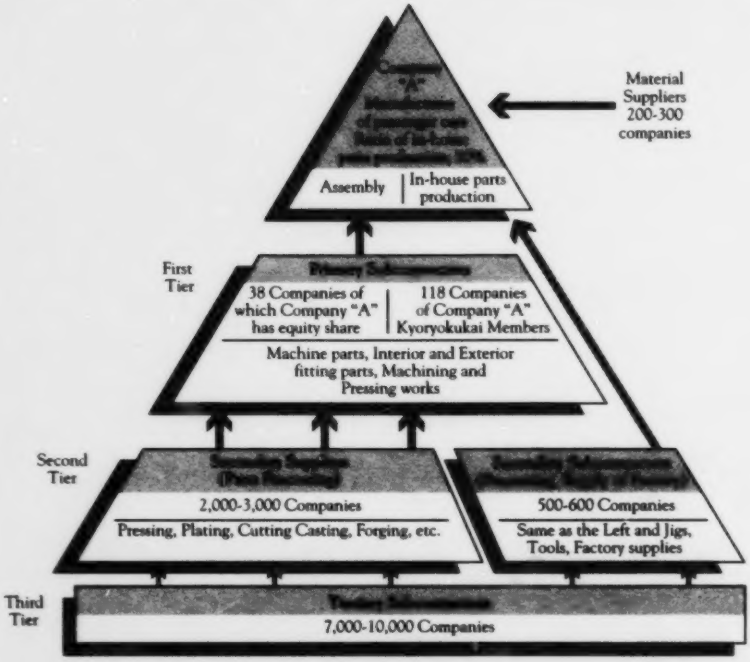
In its pursuit of high quality, Toyota extended the application of these principles throughout the entire organization, creating what is now known as company-wide quality for continuous improvement in all organizational processes. Once this was firmly established, Toyota then systematically introduced the same approach to total quality management in its supplier network.[3] This would ensure not just company-wide quality, but system-wide quality as well. Since Toyota outsourced almost 70 percent of the value of its production, its ability to lower costs and improve quality among its suppliers would eventually yield even bigger gains than had been achieved in final vehicle assembly. At any rate, it was essential that Toyota suppliers operate according to the same principles, otherwise it would be impossible for the assembly process to operate as a small-lot continuous-flow production system.

Japanese auto assemblers have tiered supply structures (see Figure 1) in which only a small fraction of the supply base deals directly with the vehicle maker. First tier suppliers are typically large, technologically sophisticated companies that play a major role in product development and sub-assembly. These supply the assembler directly and usually take responsibility for a complete parts system such as the heating and cooling system, suspension system or seating system. Hence, first tier suppliers are sometimes referred to as systems suppliers. The first tier of the supply base also translates functional requirements into products, incorporating their own product and process design capability. This leaves the vehicle maker free to concentrate on product integration, and to delegate sub-system development and integration to its first tier suppliers.

Each level of the supply structure is defined by the breadth and degree of supplier product and engineering responsibility. It is essential for first and second

FIGURE 1

PRODUCTION STRUCTURE OF TYPICAL JAPANESE AUTOMAKER AS OF 1981


Company
“A”
Manufacturer
of passenger cars
Ratio of in-house
parts production
Assembly
In-house parts production
Material Suppliers 200-300 companies
First Tier
Primary Subcontractors
38 Companies of which Company “A” has equity share
118 Companies of Company “A” Kyoryokukai Members
Machine parts, Interior and Exterior fitting parts, Machining and Pressing works
Second Tier
2,000-3,000 Companies
Pressing, Plating, Cutting Casting, Forging, etc.
500-600 Companies
Same as the Left and Jigs, Tools, Factory supplies
Third Tier
Tertiary Subcontractors
7,000-10,000 Companies

Note: 1. Ratio of in-house production

$$= \left[\frac{1 - \text{Purchase Cost} + \text{Cost of outsourcing parts processing}}{\text{Total Manufacturing Cost}} \right] \times 100\%$$

Note: 2. For each partsmaker, the number of companies to which they supply is not limited to one company.

SOURCE: Small and Medium Enterprise Agency, *White Paper on Small Business*, 1981 edition

tier suppliers to have indigenous manufacturing and design engineering capability. At the lowest level, the third tier suppliers tend to rely mainly on outside engineering capability.

The introduction of the tiered supply structure helped the Japanese cut product development time as well as development cost. As much as 80 percent of a production cost structure cannot be changed after the design stage is complete. This makes the product development stage by far the most effective place to cut costs. The design process is also subject to the same principles of continuous improvement. For example, Mazda has set a target for itself of a

TABLE 2

JAPANESE VEHICLE PRODUCTION IN NORTH AMERICA

OVERSEAS MANUFACTURING OPERATIONS

Countries	**United States of America**					
Japanese Makers	Honda			Nissan	Mazda	Mitsubishi
Type of Entry	Sole Entry			Sole Entry	Sole Entry	Joint Venture with Chrysler
Name of Company	Honda of America Mfg., Inc			Nissan Motor Manufacturing Corporation USA	Mazda Motor Manufacturing (USA) Corporation	Diamond-Star Motors Corporation
Established	February 1978			July 1980	January 1985	October 1985
Paid-Up Capital	$578 million			$375 million	$200 million	$199.5 million
Share in Equity	Honda of America 97.58% Honda 2.42%			Nissan (U.S.A.) 100%	Mazda 100%	Mitsubishi 50% Chrysler 50%
Location	Marysville, Ohio			Smyrna, Tennessee	Flat Rock, Michigan	Bloomington-Normal, Illinois
Land Area	870 acres		578 acres	783 acres	395 acres	635 acres
	First Plant	Second Plant	Engine Plant			
Vehicles/Parts Procuced	Accord Civic	Civic	Engines, Steering Components	Nissan truck (1-ton pay load), Sentra, Engines	MX-6 626 Ford Probe	Mitsubishi Eclipse, Plymouth Laser Eagle Talon
Production Start-Up Month	Nov. 1982 for 1st assembly line; April 1986 for 2nd assembly line	December 1989	September 1986	June 1983 for Nissan truck; March 1985 for Sentra; summer 1989 for engines	September 1987	September 1988
Annual Production Capacity	360,000 units	150,000 units	500,000 engines	240,000 units (440,000 units in 1992)	240,000 units	240,000 units (at full capacity)
Employees	6,300	500	1, 600	3,300 at the end of December 1989	3,500	2,900 (at full capacity)
Total Investment	$883 million	$380 million	$670 million	$745 million	$550 million	$600 million
Affiliated Technical/Design Centers	Honda R&d North America, Inc. Honda Engineering North America			Nissan Research & Development, Inc. Nissan Design International, Inc.	Mazda R&D North America, Inc.	Mitsubishi Motors America, Inc

NOTE: Data included in the table above is based on individual maker's official announcements as of May 1990.
SOURCE: Japan Automobile Manufacturers Association,member firms

TABLE 2 continued

United States of America				Canada			
Toyota	**Toyota**		**Fuji, Isuzu**	**Honda**	**Toyota**	**Toyota**	**Suzuki**
Joint Venture with GM	Sole Entry		Joint Venture	Sole Entry	Sole Entry	Sole Entry	Joint Venture with GM Canada
New United Motor Manufacturing Inc. (NUMMI)	Toyota Motor Manufacturing U.S.A., Inc		Subaru-Isuzu Automotive Inc.	Honda of Canada Mfg., Inc.	Toyota Motor Manfacturing Canada Inc.	Canadian Auto-parts Toyota Inc.	CAMI Automotive Inc.
February 1984	January 1986		March 1987	June 1984	January 1986	March 1983	October 1986
$260 million	$540 million		$250 million	C$200 million	C$250 million	C$14 million	C$202.5 million
Toyota 50% GM 50%	Toyota 20% Toyota (U.S.A.) 80%		Fuji 51% Isuzu 49%	Honda of Canada 100%	Toyota 100%	Toyota 100%	Suzuki 50% GM Canada 50%
Fremont, California	Georgetown, Kentucky		Lafayette, Indiana	Alliston, Ontario	Cambridge, Ontario	Delta, British Columbia	Ingersoll, Ontario
210 acres	1,285 acres		870 acres	450 acres	371 acres	14 acres	395 acres
Prizm, Corolla	Camry	Engines, Axles, Steering Components	Legacy (Fuji), Small truck (Isuzu)	Civic	1.6 liter Corolla sedan	Aluminum wheels	Cultus, Escudo
December 1984	May 1988	November 1988 (axles) November 1989 (engines) 1990 for steering components	September 1989	November 1986	November 1988	February 1985	April 1989
200,000 units	200,000 units	20,000 engines	60,000 units each at start-up; 120,000 units in future	100,000 units	50,000 units	480,000 wheels	200,000 units
2,900	3,000	500	1,700	1,300	1,000	110	2,500
$800 million	$800 million	$300 million	$500 million	C$280 million	C$400 million	C$43 million	C$615 million
Toyota Technical Center USA, Inc. Calty Design Research, Inc.				Isuzu Technical Center of America, Inc. Subaru Research & Design, Inc.			

fourfold increase in product development productivity over the next ten years. This means they will try to design twice as many cars in half the time without any additional staff.

Such dramatic increases in productivity have stemmed largely from innovations in organization and management, but increasingly, they are being driven by a more intensive use of automated technologies. The success of the combination of strong social organization and sophisticated technological capabilities provides the Japanese with strong incentive to introduce more productive automated systems in coming years (see Hoffman and Kaplinsky, 1988, p.171). It should be noted that this new wave of automation is an extension of the Japanese capability to adopt new technology quickly and effectively because of the emphasis on continuous learning and improvement. Automation will continue to substitute equipment for direct labour but will also lead to greater demand for, "... highly skilled problem solvers whose task will be to think continually of ways to make the system run more smoothly and productively" (Womack, Jones and Roos, 1990, p. 102).

The Japanese approach to quality and productivity improvement maximizes overall system performance through the continuous improvement of all processes. Process improvements that contribute to higher quality are also likely to yield lower costs, shorter production cycles as well as faster, cheaper and more customer-focussed product development.

ORGANIZATIONAL LEARNING IN THE CANADIAN AUTO INDUSTRY

DURING THE 1980S the auto industry was subjected to two major initiatives. In North America, producers launched a series of efforts to implement their own versions of the Japanese production system. At roughly the same time, as protectionist political pressure grew in the 1980s, the Japanese producers built plants in North America at an accelerated rate.

The 1980s were a decade of intense learning. The North Americans had to learn the Japanese manufacturing methods and strategies and both had to learn how these could be implemented in the North American production environment. Implementation required transferring technology that was embedded in organizational and inter-organizational relationships.

In order to assess the extent to which this system has been transferred to North America, particularly Canada, we begin by discussing employee learning within companies and then, in the next section, turn to how learning is transmitted between auto makers and parts makers.

LEARNING IN THE JAPANESE TRANSPLANTS

IN RESPONSE to the rapidly increasing Japanese market share in North America, governments in the United States and Canada negotiated voluntary export restraint agreements with the Japanese Ministry of International Trade and Industry. This protectionism, combined with the rising value of the yen and a desire on the part of the Japanese to locate production facilities closer to the North American market, led eight of the nine Japanese vehicle makers to invest in North American assembly operations (see Table 2). In several cases these are now being followed by engine plants. In 1989 Japanese car makers, through imports and transplant operations (including vehicles sold to North American manufacturers) had roughly 31 percent of the American market, compared to 22 percent in 1979 (*Automotive News*, June 11, 1990, p.14).

Canada has roughly 17 percent of the Japanese transplant assembly capacity in North America with CAMI (a GM-Suzuki joint venture), Honda and Toyota as well as Hyundai, a Korean assembly plant, all of which began production after 1985. CAMI is Suzuki's only North American plant, whereas the Canadian operations of Honda and Toyota are much smaller than their counterparts in the United States. Canada has proportionately fewer of the Japanese parts plants in North America, with only twenty plants compared to about four hundred in the United States (Booz, Allen and Hamilton, 1990, p. IV-9).

Japanese Assembly Operations

Although the transplant operations are essentially replicas of plants in Japan (including hardware used, plant layout, work-flow and organization), adapting them to the North American environment involved much more than workers just learning how to operate the machines. North American labour had to accept a fundamentally different relationship with management which called for a new type of flexible work organization.

Each of the transplants developed recruiting and selection procedures to identify those employees who would be best suited (in terms of attitudes and skills) to working in a Japanese-style production system. The companies also chose to locate in rural areas, presumably because workers from such areas had not been as exposed to traditional work practices and unions (Mair, Florida and Kenny, 1988, p.336). Rural workers were also likely to have less job mobility, thus ensuring that firms would retain them after training. The Canadian experience with transplants parallels that in the United States.

Of the three Japanese assembly plants in Canada, only CAMI is unionized. In that case a collective agreement was negotiated in advance of making the investment commitment to ensure that flexible job classifications and the team approach would not become an issue later on. Multi-skilling is needed to operate smoothly in a work group where jobs are performed on a rotating basis and to allow for lower overall staffing levels. For example, in the CAMI plant there are only five job classifications compared with roughly 100 in a traditional North American plant. This job flexibility, combined with incentives to encourage attendance, allows CAMI to staff and operate its plant with no more than three percent absenteeism compared to over 20 percent absenteeism in some other Canadian assembly plants.

Extensive training was undertaken at all of the transplant facilities. This included having Japanese trainers working in the plant alongside new employees and sending Canadian team leaders to Japan to be trained. The training included learning to work within the team system, techniques for problem identification and solving, statistical methods to identify sources of variance (statistical process control) and interpersonal skills. For example, at CAMI, area and team leaders were trained at two Suzuki plants in Japan. Two hundred and sixty-one Canadians, or approximately 12 percent of the expected work force, received training for one month in Japan. The trainers who instructed in Japan were then dispatched to CAMI in Canada where they worked together with the trainees to facilitate the smooth implementation of the Suzuki production system (Wolf, 1989, p. 6).

Japanese Parts Operations

Technical training requires longer time commitments. For example, F&P, an all-Japanese joint venture managed by a first tier supplier to Honda (F. Tech) has an extensive program to develop its own engineering manpower. Through their close relationship to Fukuda Engineering, an equipment supplier owned by F.Tech, F&P employees are trained in die maintenance in a twelve-month program alternating between Japan and Canada.

Employees at the Japanese plants are usually protected from technological change and frequently benefit from it by receiving additional training. When major changes in production technology are introduced, labour is reassigned or upgraded rather than displaced or deskilled. At F&P, for example, on one production line robotic welds increased from 30 percent to 80 percent as a result of the retooling for the 1991 Honda Accord. But F&P made a commitment not to lay off anyone because of automation. The "production associates" therefore received further training to operate the more sophisticated production process. This reflects F&P's commitment to develop engineering and technical manpower by upgrading its production associates. Eventually, F&P in Canada expects to match the engineering capability of its parent company.

As these examples illustrate, continuous on-the-job training has been the primary means used by the Japanese transplants to implement their labour-management system in North America. The importance of training helps to explain why the potential quality of the labour force, particularly with respect to work attitudes and aptitudes toward learning, is so important in their location and hiring decisions. The type of training provided does not confer academic credentials, thereby restricting workers' occupational mobility between firms. Although this lack of credentials represents a clear disadvantage to the workers, it is offset by the long-term commitment of the Japanese companies to their employees. In addition, the companies allow personnel on technical career paths to attain an equal level of status and compensation to those on the administrative track. This tends to prevent a drain on the technical resources of the firm and also to overcome the concern expressed by North American engineers who are forced to choose between advancement in management or a more limited technical career path.[4]

The establishment of three transplant assembly operations (including CAMI, which is unionized) and the supplier transplants such as F&P, suggest that the Japanese model of labour-management relations can be implemented successfully in Canada. However, traditional North American auto manufacturers and parts producers have found it more difficult to adopt similar practices. To begin with, they were not familiar with the Japanese system. Nor did most of them have the option to begin in a greenfield site. Instead they had to overcome more than fifty years of experience with a form of work organization based on very different principles, and a history of adversarial labour-management relations.

STRATEGIES FOR LEARNING IN NORTH AMERICAN AUTO AND PARTS MAKERS

BY 1980 THE TRADITIONAL NORTH AMERICAN PRODUCERS realized they had to match their Japanese competition or face a steadily declining market share. Until the late 1970s, all the original equipment manufacturers (OEMs) had similar operating philosophies. However, in the early 1980s each OEM met its competitive threat by adopting a distinct strategy. GM focussed primarily on labour-saving high technology. Ford, with much less capital, put its emphasis on human resources development. Chrysler fended off bankruptcy with drastic cost cutting measures and a strategy aimed at generating profits by making the most out of existing product platforms and introducing innovative new products at minimum cost. All three companies implemented quality improvement programs with varying degrees of success. All three also made strategic alliances with Japanese producers.

North American parts producers were also pressed by the new competitive realities to adopt new strategies. Some of the larger parts suppliers, particularly the multinationals, undertook quality improvement programs on their own initiative even earlier than the OEMs. However, the majority had to be prodded by the OEMs to make changes.

General Motors

The transferability of the Japanese labour-management relations model to a "brownfield" site was demonstrated at NUMMI, the Toyota-General Motors joint venture in Fremont California, which began operating in December 1984. Here, Toyota set out to implement its production system in an old GM plant, which had been shut down in 1982 because of low productivity and poor labour relations. The hiring process was very selective, although the plant was staffed from a pool of laid-off United Auto Workers, many of whom had worked at the plant when it was operated by GM. The success of the plant marked a watershed in the industry's belief in the transferability of the Toyota production system.[5] After the successful NUMMI experience, the question became *when*, not *if*, the system would be adopted throughout North America.

According to GM:

> "... in addition to being a profit center and source of product in its own right, this venture has proved enormously important to GM in helping the Corporation's managers gain first-hand experience in the worker-participation management techniques used by Asian auto manufacturers."
>
> (GM Annual Report, 1988, p.6)

Unfortunately for GM, the company was already committed to major capital programs aimed at creating high technology factories before it absorbed the lessons it learned at NUMMI. In an attempt to close the productivity gap with the Japanese, GM embarked on a ten year "strategic reindustrialization" program, scrapping or retooling old plants, and building new ones.[6] By the end of the decade GM had spent $77 billion on eight new assembly plants, nineteen "modernized" plants and twelve new stamping plants. All of this required major investments in technical training and education. In the United States from 1984 to 1989 GM committed $1.6 billion to training, education and retraining of its work force.

General Motors expected these investments to pay of in higher labour productivity, more flexibility and higher quality:

> "GM has a state-of-the-art automated manufacturing network in place, while our domestic competition has yet to face up to the cost and necessity of upgrading to prepare for the twenty-first century. Our facilities modernization program is now essentially complete, allowing GM to devote more of its resources to the product itself." (GM Annual Report, 1989, p.3)

Overall, industry analysts have judged the emphasis on technology at GM to have been misguided, resulting in haphazard initiatives and costly failures.[7] Some of GM's most automated plants exhibited the lowest levels of productivity. State-of-the-art computerized technology can be difficult to implement, and process control is very difficult to achieve without active worker participation. Most disappointing of all, perhaps, is the glacial pace of change in labour-management relations. If NUMMI had anything to teach GM it was that process and people, not high technology, are the most critical ingredients in quality and productivity.[8] Unfortunately, GM's automotive complex in Oshawa reflects this lesson. After investing over $7 billion to upgrade technology, the plant is still beset with labour relations problems.

The mechanisms used by GM to transfer its NUMMI experience have contributed to the slow pace of change. Managers must serve at NUMMI for at least three years before they are eligible to be sent to other GM plants. In an organization as large as GM, a group of 45 managers spread across the entire GM system has limited influence. At Oshawa, for example, only the Director of Purchasing is a NUMMI graduate. There is even less emphasis on learning from CAMI, the joint venture from Suzuki. At CAMI there is no formal mechanism for transferring production methods, perhaps because it is believed to be so similar to NUMMI that there is little to be learned.

Today General Motors appears to have accepted the fact that by itself, its high-technology strategy has been an insufficient response to the Japanese competition. In the United States, GM and the United Auto Workers (UAW), jointly devised the Quality Network to create a process to introduce a wide range of work place innovations. The Quality Network is intended to make GM a world class competitor, and in so doing, is to provide security for UAW workers. With the decline in UAW membership from 1.5 million members in 1979 to 996,000 in 1989, the union was highly motivated to help General Motors halt, and perhaps even reverse, the decline of its North American market share — which has fallen by 25 percent in the last decade.

The Quality Network is a set of 37 action strategies divided into six categories. It is a process for developing a shared labour-management vision within a changing work environment; it is not a program with a set of goals linked to an implementation schedule. The strategies strongly resemble the lessons from NUMMI and thus represent a systematic adoption of the lessons from the Japanese production system. Each plant in the United States has a labour-management Quality Network committee. Differences at the plant level will affect the pace at which these strategies achieve results.

In Canada the Canadian Auto Workers (CAW), which split from the UAW in 1985, declined to be identified with the Quality Network. Instead, it has opted for some similar strategies at the local plant level through what is known as the Canadian Quality Process. However, the task seems to be much more difficult in Canada given the CAW policy statement of 1989 which rejects the use of Japanese production methods in general, and specifically the use of continuous improvement and employee involvement. The CAW rejects the basic premise of international competitiveness, because it forces Canadian workers to compete with workers in countries whose real wages and living standards are much lower. Competitiveness between plants within the same corporation is viewed as pitting union member against union member. Nevertheless, when it found itself competing for the mandate to produce the new F cars against a GM plant in the United States, the CAW local at the St. Therese plant was willing to accept a reduction in job classifications, flexible overtime, and changes in training of staff on new technology. The CAW also sanctioned the use of the Japanese production system at the CAMI plant, without which Suzuki would not have established its plant in Ontario. It is unclear how far the CAW is willing to go in sanctioning changes in other Canadian plants.

Ford

Ford's strategy in the 1980s reflected the difficult financial circumstances it faced in the recession of 1982. With a bleak near-term market outlook, and lacking the funds to invest in plant modernization, Ford set out to improve its existing operations by initiating new work organization and labour-management relations programs, by increasing plant operating efficiency and by introducing bold new styling concepts. Ford also developed a deeper relationship with its Japanese partner, Mazda, in which the company has a 25 percent equity investment.

Executives at Ford's head office started learning about Japanese quality methods in the late 1970s at a series of high-level meetings in Detroit chaired by W.E. Deming, a leading American quality expert. The senior executives were eager to learn the secrets of Japanese quality and productivity. Deming was eager to discuss their corporate philosophy, and repeatedly asked them "Do you have constancy of purpose?". As a result of further senior executive soul searching, Ford developed a "Mission, Values and Guiding Principles" (MVGP) statement. This document articulated Ford's corporate commitment to quality and people, stressing participative management and employee involvement.

The next step in the process was to create a new awareness of the team approach. Supervisors and managers attended seminars and were shown how to tap the unique contributions of each employee and how to change outdated attitudes and ineffective behaviour. They were encouraged to understand how to "empower" employees in order to generate more worker involvement. A number of specific productivity and quality improvement programs were introduced, including widespread training in statistical process control for virtually all employees. An internal system of comparing employee satisfaction with the involvement program was also introduced. This provided each department with an internal benchmark to use for further comparison.

Salaried workers were also included in employee involvement activities through an in-house learning centre, a televised communication network, departmental meetings and various training seminars. The management performance appraisal system was changed so that managers could be rated on the basis of their interpersonal skills, human resource development and contribution to the team effort. Combined with the new compensation package, which included profit sharing for managers and merit pay for hourly workers, the new system provided substantial incentives for employees to learn new values and behaviours.[9]

By the end of the decade Ford of Canada had increased its commitment to all areas of training, spending more in 1989 than had been spent in the preceding seven years. This commitment included an increased focus on "Total Quality Excellence" (TQE), the aim of which is "to maintain employees' focus on the voice of the customer and to promote quality performance in every corporate task". (White, 1990, p.25)

Ford's attention to the human resource aspects of manufacturing has resulted in its plants being, on balance, the most productive of those managed by the North American manufacturers. In terms of vehicle assembly labour productivity, for example, Ford showed an improvement of 31 percent (from 4.71 to 3.25 workers per unit per day) between 1979 and 1989, while GM showed only a five percent improvement (from 5.12 to 4.88). This substantial productivity improvement in vehicle assembly, along with similar productivity increases in stamping, engines and transmissions, translated into a $629 per vehicle cost advantage for Ford in 1989 (Harbour, 1990).

The refurbished plant at Wayne, Michigan, which is patterned after Mazda's Flat Rock, Michigan plant, demonstrates that Ford can introduce flexible work organization into an existing plant. Whether similar arrangements will follow in Canada as Ford prepares to replace the Tempo/Topaz product line, will depend on how Ford and the CAW resolve issues related to work organization.

North American Suppliers

The changes in the North American original equipment manufacturers (OEMs) precipitated by Japanese competition and the newly-established Japanese parts transplants, have forced North American partsmakers to meet demands for continuous improvement in quality, cost, delivery and engineering capability. These improvements require both new technological skills and organizational capabilities. As a result, suppliers now have more selective recruitment practices, more extensive training programs and more team-based employee involvement in decision-making.

To be more competitive, partsmakers are now using a wide range of sophisticated technologies which require a more skilled workforce. The report of the Ontario Premier's Council, *People and Skills in the New Global Economy* (1990), states that the number of skilled jobs in Canadian parts companies doubled between 1985 and 1989 (from 13 percent to 25 percent) and that it is expected to increase to 32 percent by 1995. Parts companies are experiencing significant difficulties filling positions which call for skilled trades and engineering people. This was confirmed by a recent Canada Consulting survey which reported that over 80 percent of partsmakers were experiencing "some to substantial" difficulty finding skilled mechanical tradespeople — up from just over 60 percent in 1985. The same general trend also appears to apply to engineering and technical personnel. Our interviews confirmed that the widening gap between the supply and demand for skilled labour is a major worry for parts companies. There was a strong feeling that existing government training programs have not been effective in meeting the needs of industry.

Partsmakers recognize that they must now do more than simply attract skilled tradespeople. Like OEMs, they need workers who can communicate well and who have strong computational and interpersonal skills in order to work effectively in the new manufacturing environment. The aptitudes and attitudes of job applicants are as important as their formal credentials. For example, Autosystems uses an extensive interview process to evaluate an applicant's personality, eagerness to work, teamwork, manual dexterity and attitude towards quality (Premier's Council, 1990, p. 234). This is indicative of the direction being followed by most suppliers.

As previously discussed, the emphasis placed on teamwork by Japanese manufacturers is central to continuous improvement. Most Canadian partsmakers have introduced new work organization techniques such as quality circles and self-managed work groups. Indeed, all of the companies interviewed for this study had installed some form of program to increase the degree of teamwork on the shop floor. Such programs are usually coupled with others (in analytic and problem solving methodologies, for example) which can then be applied to control and improve production processes.

The Canadian subsidiary of Hayes Dana, a multinational parts maker operating in 25 countries, provides extensive training through "Dana University" in the United States. One of its key programs is "Excellence in Manufacturing", which combines six weeks of classroom study with plant tours in Japan. The purpose of this program is to train "facilitators" who use their knowledge to lead problem-solving teams at the plant level. Hayes Dana defines excellence in manufacturing as continuous improvement toward achieving "zero defects, zero inventory, zero throughtime, zero set-up time and just-in-time delivery" (Hayes Dana, 1988 and 1989). Through Dana University, Hayes Dana also has access to other specialized programs, including programs in quality engineering, manufacturing and professional development. Some of the courses even provide instruction in advanced methodologies, such as design of experiments and quality function deployment.

Tridon, a Canadian partsmaker, has devised an in-house training program — based on the concept of world-class manufacturing — for all employees, including top management, plant workers and support staff. Topics include employee participation, smart change, total quality control, total productive maintenance, kanban and group technology. Instruction is offered by "facilitators" drawn from within the existing workforce. We found this practice in most companies. Emphasis is placed on learning from co-workers rather than "experts" and on learning within natural workgroups rather than in isolation or on courses away from the workplace.

Despite apparent similarities among partsmakers, the success of their training and development programs varies considerably, not only between firms but also between plants in the same firm. This is also the case for automakers. Success seems hardest to achieve in older plants, where longstanding labour-management relations are firmly established and therefore difficult to change, and where it takes a long time for new recruitment practices to have an impact.

The process of learning which we have demonstrated is a cornerstone of continuous improvement and is essential for competitiveness in the auto industry. New plants have an advantage because they can recruit a trained or trainable work force. Plants located in areas where skilled and educated workers are in short supply must find effective and economic methods for upgrading the quality of their workforce.

A few industry-wide initiatives are now emerging which may serve as models for industry cooperation with government and educational institutions. Through the leadership of individual companies (primarily Ford) working with the American Iron and Steel Institute, a formal working group has already been commissioned to study the training needs of major metal stamping companies in North America, and to work with federal, state and provincial governments in the United States and Canada to establish a common set of educational programs. Dofasco, a Canadian-owned steel supplier to the auto industry, has also been instrumental as a partner in this initiative. By raising the level of training and education of their customers, Dofasco strengthens the market for steel while improving the competitive position of major Canadian stamping companies like A.G Simpson. It also serves to plug Canadian community colleges into a North American learning network while providing a model for educational alliances in other industries.

THE INTERDEPENDENCE OF OEM AND SUPPLIER LEARNING

SUPPLIERS PLAY A FAR MORE CRITICAL ROLE in the Japanese automotive production system than was traditionally the case in North America. When the transplant assemblers first entered North America they began by trying to replicate their supply systems. The substantial entry into the North American parts industry, particularly by first-tier Japanese suppliers, was therefore characterized by wholly owned subsidiaries or joint ventures. In response, the North American assemblers devised strategies which included reorganizing their own supply networks. North American parts suppliers were, as a result, faced with a double-barreled challenge — new competitors and new demands, both of which were imposed by a new set of customer needs and expectations.

SOURCING STRATEGIES OF THE JAPANESE TRANSPLANTS

TRANSPLANT ASSEMBLERS have pursued sourcing strategies by which they procure progressively more parts in North America, beginning with standard and bulky parts. In a series of stages thereafter, they add increasingly critical functional parts (see Table 3). This progression depends on a steadily rising number of vehicles being produced. At first, the North American parts manufacturers were unable to provide the level of quality, just-in-time delivery and continuous cost improvement expected by the Japanese. Many lacked the technical and managerial ability required to supply their products based on small-lot continuous-flow production. To assist suppliers the Japanese transplants:

1. Publicized their requirements through pamphlets, information sessions and video tapes describing North American parts suppliers who were successful in selling to the Japanese.
2. Demonstrated their willingness to work with suppliers to achieve the required level of performance. To this end, when a transplant found a potential supplier it undertook a detailed inspection of the supplier's plant and made recommendations for its improvement.
3. Helped suppliers create technology linkages with their parts suppliers in Japan, often encouraging joint ventures.
4. Established the office of Pacific Automotive Cooperation (PAC) — its mission to introduce Canadian and Japanese joint venture partners and to promote Japanese investment and the purchase of Canadian-made parts by Japanese automakers. PAC also promotes and facilitates understanding of Japanese management. For example, PAC runs a workshop diagnostic program designed to help Canadian companies understand the expectations of potential Japanese customers and business partners. It also holds annual seminars on topics such as total quality control and purchasing practices. In addition, it is now conducting a series of workshops for middle managers on "kaizen", or Japanese manufacturing technology. (Middle managers are a key group in implementing this technology.)

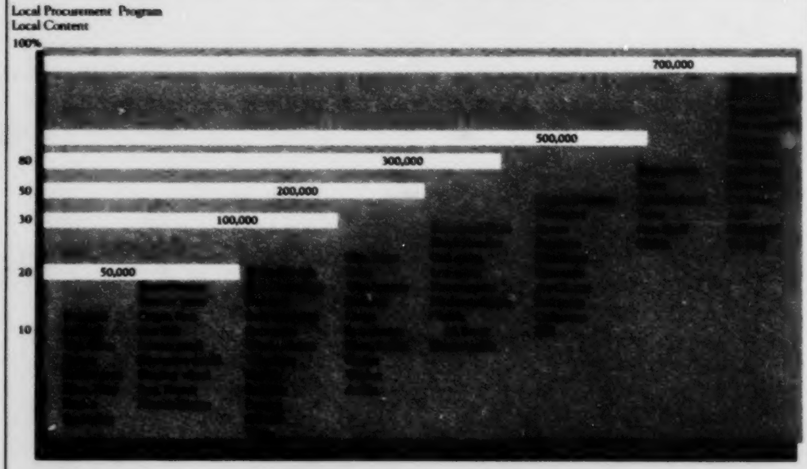
These mechanisms are not unique. They do, however, serve effectively to introduce the Japanese approach. Japanese supplier selection has traditionally taken the form of an ongoing sourcing relationship (and so takes considerably longer to establish) rather than a short-term contract This is quite different from the prevalent practice in North America which, until recently , was based on one-year contracts. Furthermore, since sole sourcing is the norm rather than the exception, and since just-in-time delivery makes parts and assembly plants highly interdependent, Japanese sourcing relationships are more like partnerships than arms'-length business transactions. As the Japanese attempt to secure more critical functional components in North America, for both the transplants and the main plants in Japan, their North American suppliers must have the same design and engineering capabilities as their suppliers in Japan. This will permit North American suppliers to become part of the assembler's primary design and engineering team.[10]

Overall, North American suppliers who have established relationships with a Japanese affiliated automaker report a positive impact on their business practices. The benefits cited in a major study sponsored by the American Government and confirmed by our own findings as well as other researchers (Dunning, 1990, pp. 34-35), include:

> "... increased production efficiency, increased emphasis on quality control, and more constant attention to product and process improvement. Some suppliers said they now felt more competitive and some were now demanding more from their own suppliers as well."
>
> (United States General Accounting Office, 1988, pp. 39-40)

TABLE 3

THE PROGRESSION OF LOCAL PROCUREMENT BY JAPANESE TRANSPLANTS



A large number of firms stand to benefit in Canada. While specific supplier lists are confidential, sources at the Ontario Ministry of Industry, Trade and Technology estimate that as of February, 1989, approximately 75 Ontario firms were supplying the Japanese transplants in North America. CAMI has the most Canadian suppliers because it alone among the transplants has gained Auto Pact status. This allows CAMI to import parts duty free, but it also obligates the company it to have 50 percent North American content.

The other two Japanese transplant assemblers in Canada (Honda and Toyota) have had less impact on Canadian suppliers because they are smaller than their sister plants in the United States, where most of the major purchasing decisions are made. It is often uneconomical to tool-up just to supply the Canadian plants. Only approximately 30 Canadian suppliers do business with the larger transplants located in the United States.

First Tier Transplant Parts Suppliers

Canadian suppliers also do business with first tier Japanese parts suppliers, many of whom have subsidiaries or joint ventures in North America. As previously mentioned, Canada has done relatively poorly in attracting these firms. Perhaps the most important reason for this poor showing is that the main action is in the United States, not in Canada. Specifically, because the Japanese auto manufacturers have chosen to concentrate their transplant assembly and parts plants in the United States, first tier manufacturers looking for a place to locate are inclined to follow the obvious lead. This is born out by the examples of Honda and Toyota; when they established large operations in the United States and smaller Canadian plants, the Japanese parts suppliers tended to gravitate to the larger American operation. In addition, imported components coming into the United States from Japan at present bear only a 2.5 percent duty compared with 9.2 percent for those coming into Canada. The United States is also a better location to obtain business from North American automakers. Like the major Japanese auto manufacturers, the Japanese parts makers are seeking to expand their customer base to achieve economies of scale as well as to diversify away from their traditional customers. For firms going the joint venture route, the United States also offers a wider range of potential partners.

F&P, of Tottenham, Ontario, is now a major supplier of stamped parts to both Honda Canada and Honda of America; it points up the implications of having a Japanese-owned parts maker located in Canada and its influence as a buyer. F&P customarily carries out technology transfer from Japan; it engages in additional amounts of product and process development work, and it develops new materials applications. By expending the considerable effort required to educate its Canadian suppliers (in terms of product and process technology, quality control, cost improvement and just-in-time delivery) F&P has upgraded the performance of its own supply base, which in North America is almost entirely Canadian. In general, F&P looks for suppliers with strong technical capabilities combined with a senior management — including the President — that takes a direct interest in operations. Although the selection process is slow and time-consuming for all, when F&P chooses a supplier, it is committed to developing that supplier the same way it develops its production associates.

As more of Honda's product development is carried out in North America, F&P's suppliers will be required to increase and strengthen their design and technological capabilities. In this connection, F&P is now working with Alcan on substitute materials. It is also working with Dofasco to adapt and improve processes to produce heavy gauge galvanized steel.

F&P (Canada) aspires, eventually, to become a North American systems supplier and to match its Japanese parent in size and technical capability. It already benefits substantially from the fact that its parent, F.Tech, has 15 "guest engineers" resident at Honda's Japanese research facility. By linking F&P to the critical early stages of product development, F.Tech provides F&P with the opportunity to be among Honda's system suppliers in North America. Each time Honda of America increases its North American engineering capability, F&P can assume more responsibility for the design role now played by its parent company in Japan. However, as F&P moves ahead with plans to become a supplier of complete suspension sub-assemblies, it is unclear whether its further expansion in North America will be in Canada or the United States, closer to Honda America and where other suppliers are clustered.

The case of F&P demonstrates the importance of being linked to the design process. Japanese OEMs still perform virtually all their advanced engineering in Japan. This represents a formidable challenge for North American parts suppliers, who have little prospect of being invited to partake in the design process without developing a presence in Japan. One option is to have an office in Japan. Although this is expensive, it facilitates communications with Japanese OEMs. Magna International, one of Canada's largest independent autoparts manufacturers, is the only Canadian parts supplier to have opened such an office. Unfortunately, that office is now closed. Another approach is to enter into a joint venture with another Japanese parts supplier.[11] This is the approach taken by the ABC Group, a Canadian company specializing in blow molding, mold making and product development. In 1987, ABC teamed with Nishikawa Kasei, a first tier supplier to Mazda, in a joint venture to which they both contribute their proprietary technology. (ABC's technology made it an attractive partner.) The joint venture brings ABC into a partnership arrangement which supplies full instrument panels to Mazda in the United States and Japan. ABC will staff and manage the Toronto plant which will supply Mazda in Flat Rock, Michigan. ABC is also stationing 15 of their engineers at the joint venture headquarters in Japan to conduct design and engineering work. This arrangement moves ABC one step closer to supplying other North American OEMs with similar modular systems.

The Woodbridge Group, formed as a result of a management buyout from Monsanto, has entered into a joint venture in the United States to produce instrument panels with the American subsidiary of Inoac of Japan. Woodbridge provides the joint venture with a production facility and a North American customer base, while Inoac contributes technology and access to the transplants. Woodbridge, which was already supplying all the North American OEMs and transplants with foam and seating systems, was quick to reach an agreement with Inoac on the joint venture. This can in part be attributed to the fact that Inoac is an independent family-owned parts supplier without strong ties to any one Japanese automaker. It was therefore unnecessary for Inoac to consult extensively with other Japanese firms before reaching an agreement. This makes Inoac an attractive partner for other collaborative projects.

THE SOURCING STRATEGIES OF THE NORTH AMERICANS

NORTH AMERICAN OEMS have traditionally been more vertically integrated than the Japanese and have placed little emphasis on developing a strong and stable base of external suppliers. As a consequence, an adversarial relationship developed, centred on price as the major buying criterion. This spirit of adversarial relations fostered mutual distrust and short-term thinking. One-year contracts, multiple sourcing and other tactics were used deliberately to weaken supplier bargaining power.[12]

Learning as an Outcome of the Quality Rating Process

Recognizing that the Japanese benefited substantially by having a strong tiered supply base, North American OEMs began to reorganize their supply networks, by developing closer, long-term relationships with fewer suppliers and emphasizing quality improvement and cost reduction through productivity gains rather than relying on bargaining power alone to obtain the lowest price. To accomplish this, the OEMs instituted a series of rating programs to measure supplier "quality". These ratings set benchmarks which enabled suppliers to assess themselves, and were used by the OEMs to decide whether or not suppliers would qualify for new business and which would be preferred.

Over time the criteria became more refined, more objective, more demanding and more comprehensive. General Motor's "Targets for Excellence" program, for example, expanded from a single rating for quality into a multidimensional scoring system based on delivery, cost, technology, and management. Suppliers achieving top marks in all five categories receive the GM "Mark of Excellence". In 1989, the first year of this award, three Canadian suppliers achieved this distinction. Ford has the most comprehensive program to date. Its "Total Quality Excellence" program uses criteria patterned on the American Malcolm Baldrige National Quality Award, and is awarded after a thorough assessment of a company or major division rather than a single plant. The adoption of the Baldridge criteria marks a critical turning point for North American manufacturers — tens of thousands of which are now beginning to use company-wide evaluation criteria set out for the Award as a tool for assessing and upgrading their own organizations' capability for continuous improvement and learning. [13]

Many suppliers interviewed indicated that the quality rating programs instituted by OEMs have been a major incentive, as well as a valuable tool in learning how to manage quality. Given that the OEMs were doing substantially more business with North American suppliers than the Japanese, their overall impact has been much greater. A.G Simpson, a large Canadian stamping company, used the rating process as a feedback mechanism to identify areas for improvement. As each plant was rated, other plant managers were invited to share the results of the lessons and then to incorporate them in their own plants. The effect was a rapid improvement across all six plants.

Academia and industry have also worked together to learn new quality methods. General Motors plays a leading role in the Institute for Improvement of Quality and Productivity at the University of Waterloo. This institute was established to help Canadian business become more competitive through the use of statistical thinking and the application of the design of experiments (DOE) for product and process improvement. It is financially supported by General Motors, its suppliers, the National Sciences and Engineering Research Council, as well as firms in other industries. GM and its suppliers benefit by having direct access to leading edge statistical tools. By using DOE methodology, GM and its suppliers have solved difficult production problems and developed new products and processes.

Supplier Councils

General Motors has also created Supplier Councils to discuss quality considerations. Aside from the interaction with GM, this provides a forum in which suppliers can learn from each other.[14] In addition to sharing information, the Supplier Councils explore the application of product design methodologies. For example, at one meeting, when the front end of a Ford Taurus and a GM "W" body car were both disassembled, it was determined that the GM car had over one hundred more part pieces than the Ford. This led to a discussion of how "value engineering"[15] could be used by both vehicle and parts manufacturers to develop better overall component systems. It also reflects the new level of design and engineering responsibility expected by the OEMs from their suppliers and is symptomatic of further movement toward the Japanese production system.[16]

In Canada some suppliers no longer produce just to OEM prints and specifications, but are responsible for more of their own drawings, prototypes and tooling. However, many other companies have found it difficult to develop their own design and engineering capabilities because they lack the people, technology and capital. An additional difficulty is that Canada is not particularly strong in terms of ability to educate design and manufacturing engineers, and because they are in great demand in other countries, they are difficult to attract. Another problem is that, although the necessary hardware and software is widely available, sophisticated and complex computerized design and communication systems are expensive and are made more so by the lack of industry standards. Given the investment risk, the high cost of capital and substantial overcapacity of the Canadian auto industry at present, it is difficult to commit new resources.

System Suppliers

A few Canadian suppliers have shown a willingness to move faster than the OEMs toward modular design and systems supply and have aggressively marketed themselves as "systems" suppliers. Before its recent financial woes, Magna International was at the forefront of the emerging system suppliers, but it has now retrenched. The trend towards system sourcing has very serious implications for second and third tier suppliers who are likely to lose business progressively as modular product designs reduce the number of part pieces. For example, the modular instrument panels that the ABC Group will soon produce contain plastic ducts molded in one or two pieces — instead of dozens as is now the case. This makes duct suppliers an endangered species.

It is increasingly likely that the manufacturing of the small pieces that remain, as well as simple labour intensive sub-assemblies, will be sourced in low wage countries such as Mexico. Therefore, if a Canadian supplier does not make the effort to be in tier one or two, it may find itself with nothing left to do. Unfortunately, a significant number of Canadian suppliers are already in this position (Booz, Allen and Hamilton, 1990, p. II-2).

Some areas of the parts supply business are not moving as quickly as others in the direction of modular design. For example, it is still unclear whether exterior trim parts will continue to be supplied to the assembler directly, or to a tier one supplier (which could be an automaker's subsidiary), who will then incorporate them into its product.

Epton Industries, a manufacturer of automotive trim parts (which was bought by managers from B.F. Goodrich in 1983), made a small but significant improvement by finding a better way to cap plastic trim ends. Through incremental innovation Epton has gradually increased its design responsibility. Thus, Epton has the potential to become a systems supplier in the event that automakers decide to purchase trim parts as a system.

A high degree of outsourcing is another feature of the Japanese tier structure which has not developed as quickly as expected in North America. GM, in particular, has returned to the view that having a strong internal parts supply system gives it a distinct advantage over its competitors. In effect, its allied parts divisions are also first tier suppliers. Even so, opportunities still exist for new sourcing relationships. For example, Autosystems of Belleville, Ontario was established by a group of former GM managers to supply GM Canada with lighting systems. It obtained technology from GM (for which it pays a royalty on sales) and has achieved extraordinary product quality. It is now looking for opportunities to expand the scope of its business into more complete functional systems. Its relationship to General Motors is a major benefit in this regard. At present, it has two engineers being trained in optic design at GM's lighting centre in Indiana. This will give Autosystems additional design capability which may be applied to future lighting system projects relevant not only to GM requirements, but to those of other automakers as well.

In some cases, suppliers have taken the lead in process development. For example, the Woodbridge Group teamed up with Inland Fisher (a GM parts subsidiary) initially to help Inland develop the first computerized information system in North America to produce and deliver seats in sequence with GM's final assembly plants. It was soon realized, however, that the new information system has a much broader applicability than its original purpose. It has now been transferred by Inland to other GM suppliers — including some who compete directly with Woodbridge. As a result, Woodbridge cemented its relationship with a key customer.

With the introduction of comprehensive OEM quality rating programs and the new "concept to customer" role played by parts suppliers, there is no longer a single key contact point between the OEM and its supplier where a buyer and a marketing representative do business. Instead, there is a combined product development and procurement process in which many actors have influence over an extended time period.[17] In effect, both the OEM and the supplier have to take a multifunctional approach within their own organization and their interaction with each other.[18]

To implement the changes required to build an effective organization and achieve system-wide quality, there must be a major commitment by leadership backed with resources and system-wide participation. Both assemblers and suppliers share the costs. Where the OEMs help develop learning capability in suppliers, the OEMs expect better performance in terms of quality, cost, delivery and product development. Hence, the benefits from learning supported by the OEMs cannot be construed as an externality to suppliers.

IMPLICATIONS FOR COMPETITIVENESS

WE HAVE PRESENTED EVIDENCE that as a result of increased organizational learning capability, substantial changes are taking place in the Canadian automobile industry. However, this does not mean that all is well. The Canadian parts industry is seriously at risk of becoming uncompetitive. Indeed, we have concluded that there is an even more serious risk of significant decline in the Canadian parts sector, because North American excess capacity is even worse in the parts sector than in the final assembly sector (Flynn and Andrea, 1989, p.18).

Among parts companies still planning to expand, a strong sentiment was expressed that their next plant will be in the United States. Tridon, a major Canadian parts supplier, recently announced that it is closing its head office and two plants[19] and leaving Canada entirely. They will relocate in Tennessee, where the company has operated a plant for over ten years. It might also be concluded that the decisions made by virtually all the leading Japanese parts suppliers to locate in the United States is a further sign of Canada's competitive weakness. As more parts plants cluster in the United States, Canada is likely to become even less competitive because suppliers benefit from being close to one another.

The emergence of Mexico as a serious player in the auto industry will compound Canada's competitive problems. Mexico has both a labour cost advantage and an increasingly skilled workforce, many of whom are graduates of technical and vocational schools. Mexican ability to accommodate the new working patterns is demonstrated by Ford's Hermosillo assembly plant, which has already achieved quality results and above-average labour productivity (Automotive Parts Manufacturers' Association, 1990, p.30) comparable to the best Japanese plants (Womack, Jones and Roos, 1990, p. 87). Parts manufacturers are now being attracted into clusters, creating an integrated production capability, to supply Mexican assembly capacity. This is distinct from the supply of low-cost parts from the Maquiladora border zone to assembly plants in the United States, where learning is not as significant a factor. As the "big three" expand their integrated operations into Mexico, they are encouraging their Canadian suppliers to follow, just as the Japanese have encouraged their suppliers to locate in North America. For its part, the Mexican government is increasing the level of training in the local workforce to create a sustainable competitive advantage as labour costs inevitably rise.

The reasons most often cited for the lack of Canadian competitiveness are exchange rates, interest rates, wage rates, tariff rates[20] and the cost of social and environmental programs (see Booz, Allen and Hamilton, 1990). While these factors are of crucial concern, none of them offers much room for improvement through independent company action. Accelerating the rate of learning has a significant effect on productivity growth, and can be acted upon by individual companies. But even so, it will take a concerted effort on the part of business, labour, government and educational institutions to make meaningful progress. It has proved to be difficult to accelerate learning because it requires new attitudes, new skills and new behaviour patterns for *all* of the actors.

DEVELOPING NEW RELATIONSHIPS AND SKILLS

WITH RESPECT TO LABOUR-MANAGEMENT RELATIONS, the CAW has chosen to follow an independent course since 1985 when it split away from the UAW. Its present posture is generally very hostile to changes in work organization.[21] Although the CAW eventually agreed to the CAMI arrangements and major changes at St. Therese (when plant closure was a real possibility), its national policy statement of October 1989 explicitly rejects Japanese production methods, including techniques for continuous improvement. If taken at face value, this policy could serve as a disincentive to invest in Canada and an incentive to invest in the United States. Mechanisms must therefore be devised to turn around the adversarial labour-management relations, particularly in large unionized plants, so that the climate for continuous learning can be effectively put in place. For example, workers have a need to be consulted about organizational change and training in order to establish initial trust as well as to get their valuable imputs. The team concept therefore is not only a challenge for organized labour. Successful implementation also depends on the ability and willingness of middle managers to embrace new managerial and organizational relationships. The power of middle managers has traditionally been based on the control of information. Now (and in future) it is (will be) based on their ability to facilitate information sharing and learning jointly with workers (see Shimada and McDuffie, 1987). The role of the middle manager must therefore change from one of control to one of facilitation.

The availability of trained and trainable employees has been cited as a major criterion in determining company location. The industry does not believe that the Canadian educational system is providing the engineers, skilled trades people, and numerically skilled and literate high school graduates it needs. In contrast, some American states help firms become established by facilitating all aspects of employee recruitment, selection and training.

The analytic and interpersonal skills used in "total quality management" are another important part of the manpower development process. The amount of education and training focussed on company-wide quality management in Canada has increased over the last ten years. However, it pales in comparison with the Japanese and falls far short of the dramatic increase in total quality management activity in the United States.

The Canadian government could follow the lead of Japan where the Deming Prize has long symbolized their commitment to quality, or of the United States where the aforementioned Baldrige National Quality Award has recently been launched. To this end, Industry, Science and Technology Canada could revise its current quality award program, which generates little notice and virtually no recognition, by adopting the Baldrige criteria, which have already become the measure against which North American industry judges its best performing companies. These steps would benefit not only the automotive industry but also both the manufacturing and service sectors.

LINKAGES AND LEARNING

SINCE THE IMPLEMENTATION OF THE AUTO PACT, Canada has been more successful in attracting assembly plants than in establishing a strong parts supply infrastructure,[22] while developing only minimal product and process engineering capability. This pattern has been repeated with recent Japanese investments. With more value-added being outsourced to parts makers and more supplier responsibility for engineering, the Canadian industry is at a competitive disadvantage. We have identified a number of strategic responses which are being employed both alone and in combination to accelerate the rate of learning in the Canadian industry:

1) know-how from strategic alliances
2) parent company know-how
3) customer know-how
4) supplier know-how

The benefits derived from these linkages depend on the degree of in-house engineering capability of the firms that use them (along with the organizational and managerial capabilities previously discussed). For example, some Canadian companies are establishing technology linkages with Japanese partsmakers. The companies that possess their own proprietary technology and have a close relationship with North American OEMs are in a strong position to forge beneficial strategic alliances. Another advantage of these linkages is that Canadian suppliers can also gain access to the North American transplants and, in some cases, to their parent operations in Japan.

Inward-bound foreign direct investment in greenfield operations in Canada should also be encouraged since it tends to carry many of the same benefits as strategic alliances. Such investment provides a channel for accessing the world's best technology (Lawrence, 1990, p.5). One should not be unduly concerned with the displacement effect since, otherwise, the investment will likely be made in the United States, and will still have the same displacement consequences. Foreign takeovers of Canadian companies are more difficult to assess, but in some cases appear to be a viable way to ensure stability in the industry. For example, Siemens of Germany, a very successful international parts supplier, recently purchased the MACI division of Magna International, thus providing Magna with badly needed capital. MACI was then folded into the operations of Siemens. Outward-bound foreign direct investment may also be needed to provide sufficient scale to justify expenditures on technology. This is particularly important where just-in-time delivery requires a regional supply strategy with parts produced near each final assembly plant.

Some impressive organizational learning is going on in the Canadian automotive industry, but can Canadians keep up with the accelerating pace of learning in the global auto industry? There is no definitive answer to this question, but there are reasons to suspect that we have not made learning a high enough priority to improve, or even maintain, our overall competitive position.

ENDNOTES

1. Europe clearly has its own substantial automotive industry. However, because of the conceptual emphasis on the North American and Japanese production systems and their impact on the North American industry, we have not included the European producers in this study.
2. The "Harbour Report" in 1980 shocked the North American industry by identifying a $1,500 cost differential between Japanese and North American made vehicles in the same class.
3. The automakers and their suppliers appear to have a relationship that has characteristics of both a market and a hierarchy. Smitka (1989) describes the relationship as "governance by trust", but with various safeguards. Womack, Jones and Roos (1990, p.167-68), aptly describe the relationship:

   "By abandoning power-based bargaining and substituting an agreed-upon rational structure for jointly analyzing costs, determining prices, and sharing profits, adversarial relationships give way to cooperative ones. Cooperation does not mean a cozy relaxed atmosphere — far from it.... Japanese suppliers face constant pressure to improve their performance, both through constant comparison with other suppliers and contracts based on falling costs."
4. In a survey of 2,000 automotive engineers, 600 cited lack of career advancement opportunity as their major cause of frustration and job dissatisfaction (Plumb, 1990, p.37). F&P's approach to technical training and advancement appears to respond to this concern.

5. In 1986, it took 19 labour hours to produce a car at NUMMI, compared to 15.7 hours at the parent plant in Japan. This substantially exceeded productivity at GM where it took 33.4 hours to produce a car in a typical old "low tech" plant and 27 labour hours at a "high tech" plant (Womack, 1988, pp. 322-324). Furthermore, quality at NUMMI was equal to quality at the parent plant (Krafcik, 1986, p.9).
6. In its quest for high technology, GM established a joint venture with a Japanese robotics manufacturer, Fanuc, in 1982 and, in 1984, acquired Electronic Data Systems Corporation to help with its factory computer integration. In 1985 it acquired Hughes Aircraft to provide advanced manufacturing technology.
7. For a detailed account of the struggle for recovery at General Motors, see Maryann Keller's *Rude Awakening* (1989).
8. In 1983 GM announced that the "Saturn Project" would attempt to be directly competitive with the Japanese. Saturn, a new GM division, was built as a rural greenfield site. It went into production in mid-1990 and may yet succeed in combining a Japanese style of team management with advanced technology in cooperation with the UAW.
9. In the United States, Ford provided considerable motivation to its hourly work force through its profit sharing plan. It paid out on average a total of $13,255 per worker from 1984 to 1990, compared to only $1,837 per worker by GM (Beier and Gearhart, April, 1990).
10. Japanese automakers (including Honda, Nissan, Toyota, Mazda and Mitsubishi) have established design and engineering centres in the United States which will facilitate greater North American supplier involvement in new car development. This is still largely confined to modifying existing products. The extent to which entire vehicle design will ever be undertaken through these Japanese centres is open to question (see Womack, Jones and Roos, 1990, pp. 201-203).
11. Magna International also participates in joint ventures frequently to gain "ready access to technology and know how" (Magna International Annual Report, 1984, p.6). Many of its partners are European.
12. This must be kept in perspective. Without the active efforts of American-owned OEMs in Canada — especially GM, which is the only company with a Canadian purchasing office — an extensive Canadian supply base would probably never have developed.
13. In 1990, Cadillac became the first division of an automaker to win a Baldrige Award. This honour, announced to employees at the Detroit-Hamtramck plant, stands in stark contrast to the difficult years in the mid-1980s when Hamtramck symbolized GM's failure to embrace the lessons of the Japanese production system.
14. This in some respects resembles the supplier associations, or "kyoryokukai", used by most of the Japanese OEMs, although the Japanese stress the social bonding benefits of these groups as well as their educational

value. In Japan, where approximately 100,000 engineers receive quality-related training every year, the forums for industry education are more highly developed.

15. Value engineering was developed in the United States in the late 1940s and is applied to the systemicatic reduction of product complexity (thus cutting manufacturing costs) and the improvement of quality and reliability. After a long decline in the United States, and refinement by the Japanese, it is one of the quality techniques currently being "rediscovered" in North America.
16. Despite improvements, it still takes North American OEMs considerably longer to design and engineer a new vehicle than it does the Japanese. This indicates a productivity gap which is particularly difficult to close given that the Japanese are continuously improving in this area as well.
17. Japanese "engineers", who are trained on the job and rotated between functions, are less specialized in only one area of expertise. This generalist orientation is an advantage when trying to integrate design and manufacturing engineering tasks, where professional barriers tend to cause communication problems.
18. For the supplier, being on the team means having engineers at the original equipment manufacturer's design centre. This becomes difficult when the process takes place abroad, as was the case in the development of the Ford Escort, in which Mazda directed the engineering in Japan. Hundreds of engineers from North American suppliers shuttled back and forth to Japan. Despite these additional costs, Ford estimates that it saved at least $1 billion by having Mazda in the lead engineering role.
19. This is not an isolated example. Other companies (eg. Fleck Manufacturing company, Sheller-Globe Corporation, Purolator Products and Kelsey-Hayes), have or are shifting production to the U.S. and/or Mexico.
20. New duty remission deals to alleviate the tariff burden are no longer permitted under the Canada/U.S. Free Trade Agreement.
21. For example, the CAW is concerned that management is introducing changes using terms which do not express their true nature. They suggest that in some cases multi-skilling is more accurately seen as multi-tasking; i.e. no new skills are added, only additional tasks. It can even lead to deskilling when simpler tasks, each with a short work cycle, are substituted for a more complex task that has a longer cycle. Shorter work cycles, when combined with a faster pace, have been linked to increased health problems such as tendonitis.
22. Canada's strength in assembly and weakness in parts production is illustrated by their respective trade balances. In the last decade, the deficit on parts ranged from $3.3 billion in 1983 to nearly $8 billion in 1986 and again in 1988. In contrast, the surplus on trade in vehicles ranged from $1.3 billion in 1980 to $8.2 billion in 1989 (Bank of Canada, August 1990, pp. S127-S128)

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DISCUSSANT'S COMMENT

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THE INCREASING PRESENCE and competitiveness of Japanese multinationals in North America has brought the issue of international competitiveness to the centre of governmental policy debates. The paper by Professors Wolf and Taylor is one of a few at this conference that focus on the topic. While enhancing the competitiveness of Canadian industry is not the responsibility of Investment Canada, promoting and attracting foreign direct investment (FDI) from internationally-competitive companies into Canada, and creating an environment that may ease the operations of foreign investors, are clearly important in reinforcing Canada's ability to compete with other countries for foreign investment. Furthermore, as Professors Wolf and Taylor note in their discussion of Canadian auto parts manufacturers, foreign investors have already instituted, and will continue to introduce, new methods of production whose impact in enhancing competitiveness of local industries is already proving to be enormous.

It is important to focus on the issue of international competitiveness because of the innovative changes in the capitalist production system initiated in Japan. These changes are often identified as indicators of the rise of a new ideology and a new system of capitalist production.[1] The focus on the production system as the core of international competitiveness is apposite. Japanese efforts to maintain international competitiveness since the Meiji Restoration (1868) have concentrated on cutting production costs and improving product quality.

Since the Japanese system involves company-wide behaviour, it is difficult to separate production technologies and managerial practices in Japan. At present, three new theories which attempt to explain Japanese strength or success, have been introduced. One is the white-collarization of blue-collar workers.[2] Japanese companies succeeded in the white-collarization of factory workers who handle non-repetitive, increasingly non-routine, and highly complex tasks with increased responsibility. As the authors clearly indicate by citing examples from North America, the development of human resources through training and "quality circle" activities played a very important role in this process. The development of "humanware" is considered to be as important as the development of hardware and software.[3] However, the white-collarization of workers could not have been achieved without the increased use of robots, computers, numerically controlled machines, and automated transfer systems, which enabled producers to engage in flexible manufacturing.

With regard to the number of industrial robots in use in 1986, Japan recorded 116,000 units, the United States 25,000, Germany 12,400, and Canada

1,032.[4] Automation is an indispensable condition of the "white-collarization" of workers. On this point, GM's emphasis on automation without any concomitant attempt to develop "humanware", and Ford's attempts to introduce flexible manufacturing with a human-resource orientation, as described by the authors, represent an important point of comparison. However, when the focus of inquiry shifts from training and quality circle activities to the white-collarization of workers , the comparison between GM and Ford may have different implications. Furthermore, inquiry inevitably extends to cover not only the content of training (multi-functional training, engineering skills, statistical process control, etc.) as mentioned by the authors, it also extends to actual participation in management, harmonious industrial relations, delegation of responsibility, decision-making styles, evaluation systems, and other management systems to keep workers' motivation high (such as welfare orientation, bonus system, salary schemes, etc.). Thus, the contrast between Japan and North America on the *degree* of "white-collarization" of blue-collar workers may become an important indicator of differences.

Another theory emphasizes that internalized skill formation is not simply the result of companies providing more in-company training, but rather a result of the growth of the concept of mutual investment within a company. A company invests time and financial resources, while workers in turn invest their time and efforts in skill acquisition. The importance of the concept here lies in the fact that both management and workers have positive and cooperative attitudes and a sense that the benefits derived from such cooperation will be mutual.[5] As the authors indicate, this concept may not be workable in Canada. If not, then do we simply wait until foreign investors move out of Canada? What system may be substituted to generate competitiveness? Is the Quality Network committee instituted by GM the answer to this question? Detailed comparisons between Japanese and new North American labour and management relations, as well as attitudinal factors, are needed.

The third new theory emphasizes the importance of horizontal information networks within a company.[6] The distribution of information through workers' networks, whether white-collar or blue-collar, allows for more efficient delegation of responsibilities, motivates workers, and consequently generates a synergy effect, cutting information acquisition and internalized transaction costs and boosting productivity. Quality circle activities, the Quality Network committee and Supplier Councils in GM, and worker involvement programs, department meetings, various training meetings, and seminars at Ford, may be what constitute the equivalent North American horizontal information networks. Detailed comparisons between Japanese and North American companies and comparisons between only North American companies should also shed important light on the difference in information flows, and its impact on worker motivation and productivity.

All of these theories accept as the central premise that the development of new innovative technology is very much based on a new ideology of capitalist production and a new information network. They indicate how important it is to shift the emphasis of inquiry to include these issues when considering production technologies. This type of inquiry will not yield a set of necessary preconditions for attaining international competitiveness. Each country must develop a system of production which best suits its needs. However, an important question here is, "Which elements of the Japanese system are importable, and which are not?". If some elements are not importable, then how can we substitute for them? Will what is substituted provide sufficient or better conditions to enhance Canada's international competitiveness? The answers to the last question lie in a more systematic analysis and comparison of North American experiences. This analysis will, at the very least, provide valuable suggestions.

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11

Technological Linkages and Foreign Ownership in the Canadian Aircraft Industry

IN THE LAST FOUR DECADES Canadian public policy concerning direct foreign investment has followed a seesaw pattern.[1] Even when concerned only with technological development, policy discourse has moved in the last two decades from restriction of foreign investment, viewing it as an instrument of technological dependency,[2] to indiscriminate acceptance of foreign investment as an automatic carrier of new technology. In actual practice, however, public policy has been more reasonable and evenhanded than its rhetoric.[3]

This paper is an assessment of the innovative contributions of foreign subsidiaries in one industry — aircraft manufacturing. It considers whether foreign subsidiaries generate upstream and downstream technological linkages within Canada. Technological "linkage effect" with other firms is considered here as the key indicator by which to judge if the activities of a firm benefit the rest of the economy. By linkage, development economists refer to requirements made to suppliers ("upstream") and sales opportunities with customers ("downstream"). Here we focus on "technological linkages", i.e. requirements for a supply of new or improved technology. Sometimes, the success of a new product comes from none of its specific components but from the close fit of all of them into a coherent system. We call this, following the French development economist François Penoux, a "junction effect".

We suggest that ownership is largely irrelevant in the aircraft industry when considered in relation to four other variables: whether the firm is mainly in the commercial or defence field; whether the firm is an autonomous subsidiary and has a world product mandate; whether the firm's parent has technology that it is willing to transfer; and whether the firm develops total systems (airplanes or engines) or just components.[4] We also examine some of the conditions that lead some foreign subsidiaries to develop a technological capability and local linkages while others do not. It should be noted that our comparison is limited to only three of the largest firms in the industry, and generalizations should not be made to smaller firms or to other industries where other conditions prevail.

Technological capability is seen as an accumulated stock of knowledge. Successful innovation is the *a posteriori* proof of its existence. Elements of technological competence are not only research and development capability, but also design skills, system integration management, value engineering, capacity to reap learning by doing and using benefits, marketing, and strategic management skills. Because of our focus on technological benefits to the country, we will concern ourselves not only with the manifestation of internal technological competence but also with the concurrent build-up of external innovative assets. Downstream linkages with lead users, upstream technologically strategic linkages with suppliers, and the supply of experienced skilled labour, including aeronautical engineers, are all factors in innovative performance.

These relationships are also effects of technological development. The lead user and/or assembler firms help their suppliers make developments and improvements. From the point of view of domestic and regional economic development, strategic technological linkages are of particular interest because they require close communication links to facilitate *ad hoc* problem-solving during joint developments. Thus upstream linkage development will often imply domestic or regional integration, while downstream linkage will imply export strength. Accumulated experience by skilled labour in one firm may eventually be used by another. Whole teams may move from one firm to another. Sometimes divisions or groups leave a firm to set up another firm — with or without the help of the incubator firm — often, but not always, in proximity.

Clearly, foreign ownership is only one variable that influences the development of a technological capability and its domestic linkages. Foreign ownership is a means to gain access to new technology, financial resources and foreign markets. But foreign ownership is only one of the possible ways to acquire new technology. The alternatives are: acquiring foreign firms, forming strategic technical alliances, producing under license, and subcontracting work. In the following comparison of three firms, we examine the specific combinations of means that each firm used. Furthermore, in the case of foreign ownership, the status of the subsidiary (autonomous or branch plant) is a discriminating variable in the evolution of its mandate and the nature of technology transfer.

Because they lie outside the scope of the public policy mandates of Investment Canada, we will briefly mention (but not dwell on) key facts such as local and parent management skills as well as locational and infrastructural environment aspects. However, the reader must keep in mind that the build-up of technological capability in and around the firm is largely conditioned by many factors: the incrementalist approach to technical learning; exploitation of the learning curve and economies of scope; labour management policies to ensure low turnover and maximum participation in product improvement; inducements for employees to start up new firms supplying component technologies to the incubator firm outside its core technology; choosing a robust engineering design that can be stretched and has a predictable trajectory corresponding to a clear market segment; matching the technology with market requirements; getting information out of lead users; selecting and developing technological capabilities in strategic component suppliers; and carefully charting qualitative and organizational leaps in the build-up from a servicing and maintenance facility to a manufacturing and fully integrated design capability. All these management factors are crucial in making or breaking an innovative firm, yet all these factors are clearly outside the reference field of Investment Canada's policy mandate.

We will study three aircraft firms: Pratt & Whitney Canada, de Havilland Canada and Canadair.[5] These firms were chosen because each is innovative and began operations in Canada during the 1920s. Pratt & Whitney Canada has been a foreign-owned subsidiary of the same parent, the Pratt & Whitney Aircraft Co. of East Hartford, Conn. (later United Technologies), for its entire history. Since its beginning, this firm has been stable with respect to both its ownership and its autonomous relationship with its parent. It was this autonomous status that allowed the firm to evolve its product mandate. Both de Havilland Canada and Canadair have had different foreign owners, and each has been owned by the Canadian government. Both firms have operated as branch plants and at arm's-length from their parents. Canadair's experience has been somewhat different from those of Pratt & Whitney and de Havilland. Canadair has been under Canadian ownership for long periods (1927 - 1946 and 1976 - 1986) and has never received as much in the way of technology transfers from its parent(s). Under General Dynamics, the parent was able — but unwilling — to transfer technology. When Canadair came under government ownership (an experience shared with de Havilland Canada), the possibility of direct transfers did not exist. Although Bombardier, Canadair's present owner, is supportive in other management respects, the company was not initially in the aircraft industry so has had to rely more on the manufacture of components under license and outside technical agreements in order to acquire new process and design technologies. (Bombardier purchased Heroux in 1972 and sold it in 1985; then purchased another aircraft firm, Short Brothers of Northern Ireland, in 1989; and LearJet, an important executive jet manufacturer, in 1990).

CORPORATE CHRONOLOGIES

Pratt & Whitney Canada

1928 - Pratt & Whitney Canada is formed as a subsidiary of the Pratt & Whitney Aircraft Co. of East Hartford, Connecticut. (Although both companies have undergone name changes over the years, and the American company has evolved as part of United Technologies Corporation, the ownership status of Pratt & Whitney Canada has not changed.)

1956 - Pratt & Whitney Canada begins manufacturing piston engines.

1957 - Pratt & Whitney Canada starts its own design activities with the PT6 program.

de Havilland Canada

1924 - de Havilland Canada is formed as a subsidiary of British de Havilland.

1937-45 - de Havilland Canada gains production capability as part of Canadian war effort.

1946-7 - de Havilland Canada begins design activities with the DHC-1 and 2.

1960-63 - British de Havilland and Hawker Siddeley (England) merge along with a number of other British aerospace firms. Hawker Siddeley dominates this new amalgamation and soon becomes the effective parent of de Havilland Canada.

1974 - The Canadian Government buys de Havilland Canada from Hawker Siddeley.

1984 - Canada Development Investment Corporation (CDIC), a Crown corporation, assumes control of de Havilland Canada.

1986 - de Havilland Canada is sold to Boeing Commercial Aircraft Co. of Seattle, Wash.

1990 - A.T.R. a consortium of state-owned French and Italian firms offer to buy de Havilland from Boeing.

Canadair

1923 - Canadian Vickers Ltd., a subsidiary of the British firm, Vickers Sons & Maxim, forms an aircraft division separate from its established shipbuilding operations in Montreal.

1927 - A group of Canadian investors takes over majority control of Canadian Vickers, with British Vickers retaining a minority interest.

1944 - Canadian Vickers' aircraft operations are taken over by the Canadian Government and incorporated under the name of Canadair Ltd.

1946-7 - Canadair is sold to the Electric Boat Co. of Groton, Conn.

1952 - The Electric Boat Co. forms General Dynamics with Canadair as a subsidiary. At about the same time, Canadair begins its first independent production program for the North Star, a derivative of the Douglas DC-4.

1951-3 - First complete co-design with Beech and re-design of whole airplanes.

1959 - Canadair undertakes the first complete design and production program for the CL-41 Tutor jet trainer.

1976 - Canadair is purchased from General Dynamics by the Canadian Government. During this year Canadair decides to proceed with the production phase of the Challenger program.

1982 - Canadair is placed under control of the Canada Development Investment Corporation (CDIC).

1986 - Canadair is sold to Bombardier Inc. of Montreal.

In the three studies that follow we show how each of these firms attained full technical capabilities in design, production and marketing. Specifically, we examine how the relationship with the parent and the fact of foreign ownership affected the internal technological accumulation of these firms over the course of their development and the resulting external technological benefits.

In terms of advanced technology or R&D-intensive industries, the Canadian aircraft industry ranks among the top five in world exports — a performance that is remarkable for a small country, and is in marked contrast to its performance in other capital goods and R&D-intensive manufacturing sectors (with the exception of the communication equipment industry). Pratt & Whitney Canada contributes, directly and indirectly, to much of this performance. Understanding the conditions of such a positive contribution by a foreign subsidiary is key to developing an effective foreign investment policy.

To appreciate Pratt & Whitney Canada's performance, elements of comparison were needed. This meant comparing Pratt & Whitney Canada not only with other aircraft firms, where at least some major environmental factors would be constant, but also with firms that had records of innovative behaviour. In this respect, de Havilland Canada and Canadair were the obvious choices. All three firms began operations in Canada (in some form) in the 1920s, and their approximation in size and records of innovations make them well suited to our study. Also, two of the firms had previously been foreign owned. For our comparison, Canadair offered as close as one could get to a domestic firm, relying essentially on licensing and external technology transfer in contrast to in-house technology transfer.

The aircraft industry has marked characteristics, therefore generalizations about other industries should be made cautiously. In general, it is characterized by a high degree of interdependence among firms. Joint developments are a rule. A firm does not develop or produce an aircraft or an engine alone, but jointly with a group of allied firms. Close linkages with the lead user and strategic suppliers are therefore inherent to the business. The industry has been characterized as a bilateral oligopoly both in terms of the relationship between aircraft manufacturers and airlines (or governments), and in terms of aircraft manufacturers and key component suppliers.[6] As we shall see, however, these close relationships do not necessarily imply industrial integration for a small open economy like Canada.

These close-knit linkages are technological partnerships in which integration and coherence of the system are crucial. The development of a new aircraft program is a long and extremely expensive process, not only because of difficulties in design and production techniques in meeting performance requirements, but also because of the demands for high quality necessary for the safety and reliability of the product. Breakdowns in aircraft are not just costly and inconvenient as they would be for trucks, cars and trains; they are dangerous to the point of being life-threatening. The aircraft industry must work at very different and much higher performance standards than other transportation equipment industries.

The necessary skills and financial resources to build an entire aircraft are beyond the reach of even very large firms. Although the aircraft industry as a whole comprises many firms, it is not the firm that produces an aircraft; rather, there is a primary network of airframe, engine and avionics firms, each connected to networks of hundreds of smaller firms. Each new development is therefore the joint project of an alliance of firms — what has come to be known as a strategic technical alliance. Firms make a "mutual investment" in a system technology. In a small open economy like Canada, the aircraft industry is a three-tier system where the smaller firms produce on specifications for the larger ones, but the medium size firms (such as Menasco - a major landing gear firm previously in Montreal, now in Oakville) are linked with foreign as well as domestic buyers. Downstream linkages are necessarily international, given that most production is exported because of the narrow domestic base. This is also the case, albeit to a lesser extent, for strategic supplier linkages in technology; given their highly specialized nature, manufacturers only require a few suppliers for each technology.

Much of the work of the firms involved in this network is specialized, as the components and planes themselves are highly differentiated. In Canada this is especially true, and there is little room in the market for overlapping of effort. Until recently, at least, the firms did not directly compete with each other. In our case, de Havilland Canada and Canadair design and produce (primarily) airframes, while Pratt & Whitney Canada's main activity is the production of small- to medium-size gas turbine and turbofan engines.

There are a number of similarities between the design of airframes and engines. There must be a close match between the airframe and the engine's power and weight, performance features, and maintenance requirements. The technological opportunities for these two segments of the industry are similarly constrained. Also, the regular practice of cooperative technological development agreements among firms in the three primary segments of the aircraft industry makes the rules of appropriation of technological developments similar. By choosing three firms in the same industry, even if they are not in the same segment, we can assume that the environment is relatively the same.

There are, however, marked differences in engine and airframe manufacturing, two of which are important to our study. Entry is somewhat easier in the production of parts, and even aircraft bodies, than in engines. Engine manufacturers are not as dependent on lead customers as airframe manufacturers are, since engines can be sold to a variety of competing airframe builders for different models. Conversely, engine manufacturers are more likely to benefit from similarities in demand from many clients and industries. In this respect, engines are in a slightly easier field of operation than airframes, although engine development takes five to six years and must anticipate airplane design.

After examining the three cases, we will briefly discuss the main features of government policy to put into context the specific policies towards foreign investment. In conclusion, we will put forward some suggestions for revising these policies.

PRATT & WHITNEY CANADA'S DEVELOPMENT OF TECHNOLOGICAL CAPABILITY

THE ACHIEVEMENT OF PRATT & WHITNEY CANADA has been that in less than 40 years it was able to build a well-rounded technological capability, including the ability to design innovative products that set the standards for its market segment, even though it started by simply servicing a local market with a repair facility. In terms of Canada's technological benefit, the company has spread from the original plant in Longueuil (near Montreal) to facilities in Toronto, Halifax and the Western provinces. Pratt & Whitney Canada now estimates that because of its use of CAD-CAM and new patterns of work organization, the optimum size for one of its plants is 500 workers. On October 29, 1990 it announced that it would further decentralize its work, shutting down its older and larger Longueuil plant.

In terms of external benefits, the firm has (downstream) supported many of the Canadian-designed small aircraft and (upstream) helped to support about 60 key domestic suppliers of components. As we suggested in the introduction, much of this achievement has been due to factors beyond the scope of this study. Some of these are: a careful incrementalist strategy of accumulating technological know-how; the search for economies of scope close to its technical base; quality control practices; the choice of a robust stretchable design to exploit various market segments; a focussed market strategy; the careful step-by-step acquisition of a manufacturing capability in 1956 and, in 1957, the design of the PT6. In what follows we concentrate only on those aspects relating to the company's status as a subsidiary. Generally, Pratt & Whitney Canada was autonomous, having very quickly acquired its own world mandate, which was allowed to evolve with time. This approach resulted in a number of advantages for the firm.

Two-Way Technology Transfer with Parent Firm

The cooperative and complementary nature of the relationship between Pratt & Whitney Canada and its parent (see below) has consistently induced technology transfer between them. Whenever Pratt & Whitney Canada embarked on a new phase of operations, it would send some of its personnel " ... down to Hartford to absorb Big Pratt know-how".[7] This occurred when Pratt & Whitney Canada began manufacturing piston spares, but the best example came in 1957 when the team assembled to design Pratt & Whitney Canada's first turbine engine spent months in Hartford learning about gas turbine technology and design.

The team talked with the engineers there, but worked on its own. The situation was somewhat constrained because Pratt & Whitney's military turbine program was off-limits to all those without American security clearances. While the Pratt & Whitney Canada engineers were in Hartford, they designed, as an exercise, what was later named the JT-12 jet turbine engine, but had no plans to produce it for the Canadian market. When they returned to Canada in 1958, the design work began for Pratt & Whitney Canada's first turbine engine, the PT6.[8]

This exchange of skills and technology was two-way and not just a case of the parent feeding information to the subsidiary. Pratt & Whitney (Hartford) soon recognized the merits of the JT-12 design and put it into successful production. In early 1961, after Pratt & Whitney Canada brought the PT6 into the prototype phase, Pratt & Whitney sent a team of six, led by Bruce Torrell, from Hartford to Longueuil to assist with the final and crucial development phase of the engine program. Pratt & Whitney Canada engineers and management had a good deal of talent and experience with design, but not with development. Torrell implemented a systematic approach of parallel alternative designs.[9] This was a major improvement over solving design problems sequentially. Value engineering criteria were applied in order to find the most economical solutions. Torrell also kept the design and development focussed on commercial market targets.

The two firms kept up the two-way communication and, "The American parent . . . often [came] to the Canadian subsidiary for technical information on and construction of the PT-6, and the Canadian firm's expertise in small gas turbines [grew] rapidly."[10] As computers became important in design and production work, Pratt & Whitney Canada sent people to Hartford to receive training in CAD/CAM.[11] Pratt & Whitney Canada continues to have ready access to the large staff of more than 1,000 scientists and engineers of its parent United Technologies which, because of its diversified base, can afford involvement in basic research in many different areas.

Know-how was also brought from other firms by personnel coming to work at Pratt & Whitney Canada. The original PT6 design team included engineers who had worked for the National Research Council, Turbo Research, Orenda and de Havilland Canada, as well as some recruited from British firms such as Bristol and Rolls Royce. The original local management had a systematic policy of careful recruitment of talent from other firms — much of it from Canada.

A case in point was the absorption of talent from Orenda. The cancellation of the Avro Arrow in 1959 had thrown 15,000 people out of work, a third of whom had been working on gas turbines for the Iroquois program at Orenda. This resulted in a tremendous sudden availability of skilled personnel, and Pratt & Whitney Canada benefited not just by hiring good individuals, but by hiring whole specialized teams who had already been working in areas where the company needed expertise.[12]

Relationship of Firm and Parent

The original reason for establishing Pratt & Whitney Canada was to better serve the needs of Canadian customers of Pratt & Whitney engines. This was partially accomplished by the choice of location: Montreal was close to Hartford and linked by rail, and was already a centre of aircraft activity. More important was the recognition on the part of Pratt & Whitney that an autonomous subsidiary could better serve the Canadian market, which imposed special demands because of longer flights, colder climate and shorter landing strips. Pratt & Whitney Canada was therefore given a free rein in its local management decisions, and allowed to retain 80 percent of its earnings. This enabled the firm to grow in size, develop its skills and evolve in its product mandate.

The extent to which Pratt & Whitney in Hartford foresaw such a large role for its subsidiary is debatable. When Pratt & Whitney Canada began manufacturing piston engines, that segment of the aircraft engine market, although still an important source of revenue, was declining as the jet engine market was growing. Also, it was too soon for Hartford to foresee the extent of the coming demand for small turbine engines that later became the primary market for Pratt & Whitney Canada.

Autonomy by itself is not necessarily beneficial and to understand the value of it in this case it must be placed in a fuller context. The complementary activities and mutual support systems at Pratt & Whitney were part of a relationship based on the rationalization of production and technical capabilities. By not operating Pratt & Whitney Canada as a branch plant, the two firms were each in stronger positions to develop and serve different markets. Rationalization of production was the reason for the decision in 1966 to make Pratt & Whitney Canada the only source (worldwide) for piston spares for all Pratt & Whitney engines.[13] This allowed the parent firm to concentrate on its work on large turbine engines. Pratt & Whitney Canada's expertise today in small turbine design and production technology is such that the policy of the parent firm is to have it build all turboprops and turbofans up to 8,000 lbs. thrust.[14]

This relationship gave the firms an advantage when a project arose that required cooperation and joint development, as they could proceed from a base of familiarity with each others' skills and operations, and the absence of mistrust that might have existed between firms that were used to being rivals under other circumstances. For example, in 1966, the Canadian Government awarded a contract to Pratt & Whitney Canada for complete propulsion systems for some of its destroyer fleet. The entire system, as well as one of the engines, was designed by Pratt & Whitney Canada, but both of the engines were built by Pratt & Whitney in the United States.[15]

Opportunities for rationalizing capabilities have also existed in such activities as the testing of engines in flight, before and after certification. Pratt & Whitney Canada recently modified an old Boeing 720B for use as a flying testbed. The plane was fitted with a special nose mount for turboprops (PT6s and PW100s up to 5,000 shp); a sidemount for the PW300, other turbofans, and auxiliary power units up to 10,000 lbs. thrust; and wing mounts for larger engines. One of the engines to be tested is the V2500 turbofan from International Aero Engines, a consortium that includes Pratt & Whitney (U.S.). The size of the Boeing allowed Pratt & Whitney Canada to fill the interior with specialized monitoring equipment for each engine type, and the parent firm has gained by having access to this superior capability.[16]

Two-Way Collaboration With Other United Technology Firms

Pratt & Whitney is the lead firm in United Technologies Corporation, which includes a number of other aerospace divisions and subsidiaries. The linkages that Pratt & Whitney Canada has formed with its affiliates in United Technologies have been instrumental in the growth of the firm and resulted in numerous innovations.

In the late 1960s, Pratt & Whitney Canada developed the TwinPac, a combination of two PT6 turboshaft engines, specifically for application as a power plant for U.S. Military Helicopters. However, the Senate Armed Services Committee had placed restrictions on buying engines from foreign companies. To get around the "Buy American Act" and political requirements, Pratt & Whitney Aircraft Canada started up a subsidiary of its own in West Virginia, and by assembling, testing, or overhauling a combination of Canadian-made parts and American-supplied components, this American subsidiary was able to meet U.S. requirements.[17]

More recently, in a similar development, Pratt & Whitney Canada designed compressor and power turbine components as part of the joint project for the P&W/Textron Lycoming T800-APW-800 engine, also aimed at the U.S. Army helicopter market. Pratt & Whitney Canada intended to manufacture the components, and assemble them at Pratt & Whitney's West Palm Beach, Florida division, which also handles military work for the United States.[18] The contract, however, was finally awarded to Garrett.

The expertise of Pratt & Whitney Canada in small turbine technology resulted in an important linkage with Hamilton Standard of Windsor Locks, Connecticut. Hamilton Standard had a contract to design and build auxiliary power units (to supply power for heating, air-conditioning, pressurization and the starting system for the main engines) for the Lockheed 1011. Pratt & Whitney Canada developed a variant of the PT6 as the power plant for these units. This marked the first time that an engine developed for aircraft propulsion was adapted for such use.[19] But this was not the first instance of technology transfer between these two firms. During World War II Pratt & Whitney Canada was given free access to Hamilton Standard's propeller technology.

Another division of United Technologies, United Aircraft Corporate Systems Center, was involved in developing alternative applications for Pratt & Whitney aircraft engines. They saw the potential of using small light-weight turbine engines to power high-speed trains, but first had to design an innovative pendulum suspension. This allowed the turbo train to achieve higher average speeds than conventional trains without the need to improve the tracks. Pratt & Whitney Canada supplied the ST6 variant of its PT6 as the power plant, and subcontracted work on the Canadian version of this train to Montreal Locomotive Works.[20] The project, however, was unsuccessful.

Minimizing Failures and Dead Ends: Limited Spin-Off

Although United Technologies does have explicit policies to encourage spinning off firms outside its core technology (100 such small firms have been spun off), none has occurred in Canada around Pratt & Whitney Canada. But spin-off can be seen in two ways. Fairchild spun off so many firms in California's Silicon Valley that eventually one of its own spin-offs took it over. Spin-offs may be seen as a benefit for the region, but as a failure of the firm to internalize its technological benefits. Pratt & Whitney Canada has not experienced the failure of any of its engine programs, although some of the applications that have been tried have turned into dead-ends. Although technical problems were often encountered, the dead-ends were generally because of external factors such as political, economic or non-market decisions. Because the PT6 had such a broad consumer base, the effect of a dead-end application was minimal as only the development costs of that application — and not the entire program — were lost.

Pratt & Whitney Canada rarely engaged in product development outside its main market segment and was therefore familiar with the responses of its competitors. Entry into a new market would have meant, in addition to the technical requirements of bringing out a new product, taking on new competitors with whom the firm was not familiar. An order for 60 devices to secure helicopters to a landing pad was one exception to this rule. Paradoxically, perhaps, it is the very care in focussing its activities and not spreading itself too thin that has resulted in Pratt & Whitney Canada not generating a spin-off firm from its own activities, and therefore generating fewer technological externalities.

Incentives to Labour Participation and Minimizing Turnover

Similarly, since the very long 1974 strike, Pratt & Whitney Canada has developed progressive labour-management relations. Combining monetary and non-monetary incentives, it has attempted to get the most out of the experience of its work force. Investing between $7 million and $8 million each year on training, it also grants leave to employees to acquire graduate degrees, often paying for their studies. A policy was instituted to overcome departmental rigidities so employees from various areas may participate in the same project and be directly responsible for quality. Also, any employee can ask a question of a senior executive and be entitled to a direct answer. Results of these policies are seen in increased productivity, improved products and reduction of turnover. Here again, lower labour externalities are the result of success in internalizing technological benefits.

Supplier Linkages

Although internal and direct economic benefits to the country are obvious through employment, sales and export figures, indirect benefits are more difficult to assess. Upstream inter-industrial effects do not appear in the secondary literature and are hard to document. From our own work on innovation, however, we know that prior to 1979 Pratt & Whitney Canada supplied itself with key components from within Canada more regularly than did Canadair. The confidentiality condition under which this information was obtained does not permit us to be more specific. We can, however, give some general assessment of the situation.

Industrial marketing literature shows that supplier-user relationships are long-standing ones.[21] This is also the case in innovation linkages between suppliers and users. Because technological and appropriation uncertainties raise potential transaction costs, innovative firms tend to use the same suppliers once mutual experience has reduced transactions costs.[22] Increased technological change and more rapid product life cycles have induced streamlining the supplier base and offering longer contracts with more technical aid. Thus Pratt & Whitney Canada's key components, such as fuel controls, bearings, blades, electrical circuits, transmissions, brake units, machinery, and numerically controlled machine tools, come from regular suppliers with whom it has long-standing technical relationships. A few of these are in Montreal, one is in Ontario, and the others are in the United States.[23] Recently some components have come from Japan, South Korea and Poland. Aside from innovation linkages, the foreign content of Pratt & Whitney Canada's engines has been estimated to be between 15 percent and 50 percent.[24]

The policy with respect to Pratt & Whitney Canada suppliers has been explicit. United Technologies has a supplier council that evaluates a potential supplier and the technical assistance it needs. The Ministry of Industry, Science and Technology Canada (I.S.T.C.) has set up a supplier development committee with Pratt & Whitney Canada with the aim of matching and developing technological capability. The goal is to streamline, relocate and re-source. The competition for suppliers' production capacity is fierce, and any technology that a client can bring is an extra incentive to do business. The increasingly technical content of these relationships increases the need for flexible communications that will facilitate problem solving, quality control and systems integration. This in turn increases the need for communication proximity and durable relationships. To date, Pratt & Whitney Canada estimates to have nurtured a pool of 60 strategic technology suppliers in Canada, and may yet attract other foreign subsidiaries to locate nearby in order to supply components.

One particular example gives some insight into the attention Pratt & Whitney Canada pays suppliers, especially Canadian ones, as part of its global strategy, and the learning experience that suppliers gain from this effort. In the late 1970s unpredicted increases in demand throughout much of the aviation industry found many aircraft firms caught with a shortage of "spindle capacity". As a result, they had to look for more outside suppliers for machined parts. Pratt & Whitney Canada sought out 30-35 new firms to add to the 240 Canadian firms that then constituted 50 percent of their vendor base (the rest being in the United States). Due to the necessity for very high quality in aircraft parts, as well as requirements such as full traceability of materials used in components, firms wishing to supply components must be thoroughly "audited" and "qualified" before being given any work:

> "They will not only want to see your books; they will look at your plant facilities, your equipment and your personnel. If you thought you had a pretty good facilities brochure, wait until you see the prospectus Pratt & Whitney will fill out on you. In fact, getting checked out by the aircraft industry might be the best thing that ever happened to you, even if you never get to do a single job of work, for they have been known to end up knowing more about you than you did yourself, and they are not reluctant to tell you about it."[25]

User Linkages and Junction Effects

Pratt & Whitney Canada's start in this country was based on the reputation for reliability of the piston engines from Hartford. The firm rapidly built on that reputation by providing Canadian users of these engines, at first mostly bush pilots, with excellent repair and replacement services. This reputation for servicing, in turn, had much to do with the preference that airplane buyers often expressed for new models to be equipped with Pratt & Whitney engines. When Pratt & Whitney Canada started to manufacture its own engines, the pride that it took in its engine work was expressed in the strong desire to use the Eagle emblem, which was the symbol of quality of the parent firm.[26] Repair and overhaul work continually provided opportunities for user feedback. This information was used to improve servicing and, later on, incorporated into design and modification work.

The attention to clients' needs after delivery of products was matched by a close attention to future market needs. Most small plane manufacturers have used Pratt & Whitney Canada engines and dealt with the firm, none more so than de Havilland Canada. That firm's first original bush planes, the Beaver and Otter, used Pratt & Whitney Wasp piston engines. De Havilland was also one of the early users of the PT6, which it first used to upgrade the performance of these planes in the form of the Turbo Beaver and the Twin Otter.

Another firm, Saunders Aircraft, was formed in Montreal in 1969 to undertake turboprop conversions of the British de Havilland DH-Heron. The conversion consisted of replacing the four Gipsy Queen piston engines with a pair of PT6s and lengthening the fuselage by eight feet. A number of other firms carried out conversions of other airplanes by replacing the old engines with PT6s.

Pratt & Whitney Canada engines contributed to the development and success of many new aircraft, both in Canada and abroad. For example, the Beechcraft King Air 6-8 passenger business plane was powered by twin PT6A-6 turboprops. Much of the high initial acceptance of this plane was attributed to the engines.[27] The coupling of two PT6 turboshaft engines into the TwinPac, done in association with Bell Helicopter in the United States,[28] provided this helicopter power plant with an extra measure of safety. When Pratt & Whitney Canada introduced its first turbofan jet engine, the JT15D, the first order went to Cessna of Wichita, Kansas. That firm used the engine to power its first executive jet, the Fanjet 500.[29]

Many of these aircraft would not have had the same success were it not for the close match of the engines to the specific airframe requirements. Hence the successes of these innovative aircraft were not due to either the frame or the engine, but to the junction effects between two innovations. We will come back to some of these effects when we examine de Havilland Canada.

Appraisal

The autonomy of this subsidiary had all the characteristics that can make foreign ownership an advantageous way to gain access to new technology and markets: two-way technology transfer with the parent and its affiliates, an evolving international product mandate concurrent with an encouragement to service the specific requirements of the host country, and the involvement in whole systems design and production. The two latter features have ensured the growth of domestic downstream and upstream linkages.

DE HAVILLAND CANADA'S DEVELOPMENT OF TECHNOLOGICAL CAPABILITY

THE COMPARISON OF DE HAVILLAND CANADA with Pratt & Whitney Canada is interesting in several respects. The firms had similar early histories, both in terms of the kinds of work they did and the autonomy of their management.

The continuous ownership of Pratt & Whitney Canada provides a contrast to the different ownership experiences of de Havilland Canada. Both firms have histories that include progressive reliance on employees' creativity and protracted labour strife. The continuous progress of Pratt & Whitney Canada is also in contrast with the arrested development of de Havilland Canada's technological capability in the 1970s. And the compatability of the firms' products after World War II, when they began to design and build their own products, led to a strong symbiotic relationship. The two firms have frequently worked on common projects.

The technological performance of de Havilland Canada is also mainly affected by local and foreign management skills. This influence can be seen in the strategy of careful incrementalism, utilization of internal skills (or lack of attention to labour-management relations), and targeting the predictable technological trajectory of short take-off and landing (STOL) aircraft by means of a robust design. As well, market segments have been less well focussed, there has been some diversification away from its technical base and, until recently, less attention has been paid to process technology. However, we will concentrate here on those factors related to foreign ownership and linkages. De Havilland Canada also started as an autonomous subsidiary and benefited from the advantages of this type of status.

Two-Way Technology Transfer with Parent Firms and Affiliates

Although subsidiaries often perform less R&D of their own than large independent firms, in-house transfers may be of great assistance in the build-up of technological capability, in particular to the threshold necessary for the design and development of new airplanes. Like Pratt & Whitney Canada, de Havilland Canada was helped in this process by its first parent, British de Havilland; but, in contrast, it did not receive this type of help from its subsequent owner, Hawker Siddeley.

The earliest technology transfer came in the form of the kits themselves that were sent from the parent to the subsidiary for assembly. It was through this work that de Havilland Canada gained understanding of the design and manufacturing of aircraft. By the early 1940s, Phil Garratt, the head of de Havilland Canada, wanted to bring the firm to the point where it would be able to meet the production demands of Canada's participation in WW II and could design its own aircraft. He requested some assistance from the parent firm and British de Havilland complied by sending a technical team consisting of two of its best designers, W.D. Hunter and W.J. Jakimiuk, and a very able group of expatriate Polish aircraft engineers.

Another technology transfer was related to missiles. Around 1956, prompted by the fact that they had access to the technological expertise of British de Havilland Propellers Ltd., de Havilland Canada established a Guided Missile Division. This Division worked on the installation of the avionics system of the

Grumman Tracker, the Velvet Glove and Sparrow II missile projects (for the Avro Arrow), and other missile work with the U.S. Navy and British de Havilland Propellers.[30]

As de Havilland Canada's technical capabilities grew, the parent firm was also able to benefit from reverse technology transfer from its subsidiary. In 1959 British de Havilland asked for assistance on design work for its D.H. 121 Trident airliner program, and an engineering team was sent from Canada. Their year's stay in England resulted in two-way technology transfers as they brought back with them what they had learned. Another team was later sent from de Havilland Canada to help with the production engineering for the D.H. 125.[31]

These loans of personnel served another important function in addition to the exchange of technical skills. They came at a time when de Havilland Canada was cutting back on its staff due to the completion of some large military contracts. Instead of losing these skilled employees, de Havilland Canada was able to retain them while it weathered the low phase of an employment cycle.

Since World War II de Havilland Canada's primary activity has been the design and production of various types of STOL aircraft. In this venture the firm has received considerable assistance from the National Research Council. Much of its expertise in this technical system has been generated internally, but it has also gained from work with other firms on technologies closely related to STOL. One of the objectives of these collaborations has been to achieve vertical or short take off and landing (V/STOL) capabilities in aircraft by various means of directing some of the engine thrust downward to provide extra lift.

Research on one approach to this problem, the augmentor wing, had been underway at Avro Canada and when that firm shut down, the project head, Don Whittley, moved to de Havilland Canada.[32] Thus the demise of Avro Canada resulted in some external benefits for de Havilland Canada. The program was expanded in 1965 to include the National Aeronautics and Space Administration (NASA) in the United States and the Department of National Defence in Canada.

De Havilland Canada continued its research in this technology through subsequent joint efforts, which provided further opportunities for technology transfer. One of these was a program administered by NASA and the Department of Regional Industrial Expansion. De Havilland Canada worked with Rolls Royce of Canada to build and install an Ejector Lift, Vectored Thrust (ELVT) propulsion system for a modified DHC-Buffalo.[33] Later, in 1972, the program evolved into a joint project between de Havilland Canada and Boeing on the augmentor wing, using Boeing's flight testing facilities in Seattle, Wash.[34]

External linkages are not necessarily beneficial to either party and the value of the linkage can also vary for the same two firms under different circumstances. The work that de Havilland Canada did with Boeing on the augmentor wing was technically sophisticated. In 1972, the two firms also entered into a marketing arrangement in which it was thought that de Havilland Canada's small commuter planes would complement Boeing's large jets in Boeing's sales efforts. Some assessments of the benefits of this arrangement were favourable,[35] but others were not, " . . . de Havilland figured it was a waste of money. Russ Bannock, President of de Havilland [said] during that period, Boeing wasn't all that helpful to us".[36]

There had been collaboration between Boeing and de Havilland Canada before Boeing's acquisition of the firm and this may continue after its proposed sale. In the recent four-year tenure of Boeing, the parent company has transferred process and management technology and invested $300 million in upgrading facilities, thereby increasing the production capacity from one to five planes per month, and reduced most suppliers' prices by 25 percent. Despite the fact that in 1990 de Havilland had 100 orders to deliver over for the next three years with few gaps in its load, it is not making a profit.[37] On the other hand, however, it is unclear whether de Havilland Canada has brought any technology to Boeing other than its experience in the production of commuter planes — a narrow market segment for planes having between 19 and 100 seats with a range of under 500 miles.

In the light of the A.T.R. consortium's recent offer to Boeing for de Havilland Canada, one can speculate on what these firms could bring each other technologically. The Dash 8/300, with 36-50 seats, and the Dash 8/400 overlap with the A.T.R., with 43-72 seats, and in this respect they are close substitutes. In terms of models, only the smaller Dash 8/100 is "bullet proof" and offers A.T.R. a wider product scope.[38] With American Eagle buying 100 A.T.R.s Aerospatiale and Aeritalia will have their order books jammed and no slack capacity, so de Havilland Canada may offer some excess production capacity in the short and medium term. Part of this production capacity is in the supplier base, which is 70 percent in Canada. Furthermore, the firm would become the leader with between 40 percent and 70 percent of the market — depending on the definition of the market segment. This may provide a margin for a five percent price increase, which should finally allow producers to make ends meet and possibly achieve a profit. Price leadership in a market that is estimated at 25,000 planes by year 2000 might be desirable, but to date, it is unclear how price elastic this segment of the market is, and to what extent price increases would be adhered to by the competition. Nonetheless, A.T.R. can bring de Havilland Canada an international connection that it has always lacked in spite of repeated efforts. In the longer term, however, Aerospatiale can bring CAD/CAM technology (which Boeing did not transfer), and organizational skills in work processes. De Havilland Canada can provide hydrodynamic skills and — with National Research Council support — better wing design capabilities (which make their planes fly faster with the same engines) and noise abatement technology. Both firms are acquiring experience in composite materials — an area of great uncertainty which led A.T.R. to recall and redesign 150 planes with wing fatigue failures. The major question is what will A.T.R. do with de Havilland

Canada's design capability, which was acquired over time at such costs? Because the two partners in A.T.R. are government-owned firms, the issue of the future autonomy of de Havilland Canada is even more important.

Status: from Autonomy to a Contract Firm to Narrow Mandate to... What Next?

From the start, British de Havilland believed that each of its subsidiaries should first serve the domestic market where it was located:

> "The central policy for each of the overseas companies had always been to serve aviation in the land of its adoption. The same view continued through the war years. Frank Stanley, de Havilland Canada's man of finance in the 1950s, described this parent/branch relationship after the war: 'The parent company never expected any returns from us,' he said, 'and resisted the efforts of British banks to acquire Canadian profits. De Havilland England made loans to us from time to time and were repaid, but held the policy of ploughing profits (whenever there were any) back into the next design project. Their aim was self-sufficiency, not a source of head office revenue.'."[39]

For de Havilland Canada this meant, at first, developing light utility and taxi aircraft with short take off and landing (STOL) characteristics for use in the bush and, later, small transport and commuter planes. Under British de Havilland, de Havilland Canada was allowed to concentrate on these market segments, and did so very successfully.

Only after the Hawker Siddeley takeover in 1960 was there a change in this direction. Under British de Havilland, de Havilland Canada had enjoyed a similar relationship to its parent company as had Pratt & Whitney Canada — substantial autonomy to invest in its own R&D and develop independent products. Hawker Siddeley, by contrast, took a direct role in the management of de Havilland Canada, sending steady streams of directives from the head office in England. Regrettably, these directives reflected the wish of the parent firm to avoid competition from its subsidiary rather than a strategy of complementary product lines from the two firms. Hawker Siddeley saw de Havilland Canada's role as that of a branch facility for contract work. The impression this often gave to de Havilland Canada personnel and the Canadian Government was that Hawker Siddeley intended to close down its subsidiary altogether.

The relationship continued to deteriorate during 1969, when de Havilland Canada completed the initial design work for the Dash 7 and wanted a manufacturing partner. De Havilland Canada first approached SAAB of Sweden (who declined) and then Messerschmitt Bolkow-Blohm (MBB) of Germany. Hawker Siddeley had two competing aircraft, the HS-748 and the proposed HS-146. Rather than enter into some kind of joint development program (as Canadair did when its subsidiary Short Brothers was developing a Regional Jet), Hawker Siddeley sent directives to de Havilland Canada advising that they did not wish them to pursue the Dash 7. They had already issued one directive halting production of the Turbo Beaver. Nor did Hawker Siddeley offer support for any other ventures:

> "For the first time in 42 years a major difference of opinion had arisen between the parent company and its Canadian branch, and the situation was also beginning to strain the good relationship that had always existed between DH Canada and the government in Ottawa."[40]

As we shall see, the federal government ensured continued STOL development, first through funding and then, in 1974, by taking over de Havilland Canada with the goal of restoring the firm to a viable state. The government sold de Havilland Canada to Boeing in 1986 and Boeing, in turn, put the firm up for sale in 1990. During the four years under Boeing's management, de Havilland Canada was streamlined, passing from four products to only one (the Dash 8), its factory modernized at considerable cost, the component costs reduced, the production capacity increased by a multiple of at least two to five, and its market expanded. STOL technology was for all intents and purposes dropped because of the lack of need for it, given the airports in use at the time. The saturation of the bush plane market by de Havilland Canada's past success in Otters (850 are still functioning) did not leave any space for use of the STOL technology in this market and restricted de Havilland Canada's business to repair and overhaul. Boeing had actually given de Havilland Canada a world product mandate but in a very narrow market segment. This may have been partly because in Boeing's judgement it was not worthwhile to produce a jet with under 150 seats, or a turbine plane with fewer than 100 seats, and the narrow market in between was not lucrative enough. Boeing (Seattle) had its own challenges (full order books and capacity problems) that made it attractive to unload the headaches of producing commuter airplanes. Seattle wished, in the process, to retrieve some of what could become an irretrievable investment — sunk costs.

The offer by the government-owned Aerospatiale and Aeritalia to Boeing for de Havilland Canada involves negotiations among four parties: a dominant multinational corporation, two governments, and a subsidiary that happens to be a strategic asset for Canada. The stakes are also very unequal for the parties involved. Boeing wants a return on its investment, and the French and Italian firms want to establish a base in the North American market in order to dominate a market segment. The Canadian government must consider the future of strategic technological assets in and around the firm. In order to guarantee future autonomy, an evolving mandate, two-way technology transfer, total systems design and the maintenance of a design capability (and possible advance design teams), it may be necessary for the Canadian government to secure some commitment directly with the French and Italian governments through technological agreements.

Economies of Scope, Diseconomies of Scope and Spin-Offs

De Havilland Canada had established a reputation, even before World War II, for its specialized skills in shaping metals. This was an important technical asset for its aircraft work and also led — through a combination of incrementalism, technology transfer, and the search for economies of scope — to the incubation of new technologies, organization to promote them, and eventual spin-offs.

De Havilland Canada continually improved its skills in solving difficult design and fabrication problems in metal. In the late 1950s, de Havilland Canada's Guided Missile Division, through British de Havilland Propellers Ltd., found new applications for these skills in missile and satellite work. In 1960, the name of the Guided Missile Division was changed to the Special Products Division. Projects included the STEM (Storable Tubular Extendable Member), a self-storing and self-erecting antenna for use in space and on land, and the Alouette I, Canada's first satellite, on which de Havilland Canada worked with a division of RCA in Montreal (later bought by SPAR). The division was the lead member in the DCF (de Havilland - CAE - Ferranti) Systems consortium formed with CAE of Montreal and Ferranti Packard of Toronto to work on the installation in Canada of Boeing Bomarc missiles. In 1962, the Special Products Division acquired Canadian Applied Research (formed in 1947 as part of Avro) and changed the name to the present one, SPAR. In 1969, SPAR became an independent company. A number of de Havilland Canada personnel, including the division head, Larry Clarke, left de Havilland Canada to remain with SPAR. The company is now best known for the design and construction of the Canadarm.

Another de Havilland attempt to diversify resulted in exceeding its market focus. In 1962, at the urging of Hawker Siddeley, de Havilland Canada had taken over the old Avro plant in Malton, Ontario. Having these facilities led to de Havilland Canada securing a large subcontract with Douglas Aircraft of California to build wings for the DC9. Fulfilling this contract proved to be a drain on de Havilland Canada and took it too far afield from its area of technical expertise. The problem was resolved in 1965 when Douglas took over the whole operation by forming the Douglas Aircraft Co. of Canada.

Not all searches for economies of scope were so successful or beneficial to the country. Sometimes de Havilland Canada strayed far from its technical scope and its technological and market focus. Although all of the work undertaken did in some ways contribute to the collective experience of the firm, there were some notable dead-ends. The Bras d'Or was a 200-ton high speed anti-submarine hydrofoil ship developed by de Havilland Canada for the Canadian Navy. It was a technical success but was shelved by the government, as were many other hydrofoil technologies. The Bobcat was an amphibious tracked armored personnel carrier and transport. De Havilland Canada painstakingly built twenty Bobcats for Hawker Siddeley, but they never went into production.

User Linkage and Targeting New Products: Utilization of Downstream Information

De Havilland Canada had always paid careful attention to user feedback, in both original design work and adjustments. This not only resulted in user benefits, but also helped to demonstrate the performance value of de Havilland Canada's designs to prospective users. Just as de Havilland Canada had been heavily influenced and encouraged by the Ontario Provincial Air Service (OPAS) in the design of the Beaver (OPAS served as the launch customer), the external link with Max Ward was also important. Ward had previously started his own air service using a Moth that he bought from de Havilland Canada. His suggestions for the DHC-3 Otter, and his 1952 purchase of one of the first Otters, not only helped the success of that design but also was pivotal in the establishment of his new air service that eventually became Wardair.[41]

Canadian climatic and topographic conditions indicated the need for an all-metal plane that could operate on floats and skis as well as on rough and short runways. De Havilland Canada had taken advantage of the fact that Canadian operators were excellent sources for information on aircraft design requirements. OPAS was the first customer for the Beaver and had given de Havilland Canada many suggestions about what it needed in a plane. Many of these ideas, as well as those resulting from a poll of bush pilots and prospectors undertaken by de Havilland Canada, went into the design of the Beaver.[42]

Other such linkages were with the Denver-based Rocky Mountain Airways,[43] who developed a microwave landing system for its six Twin Otters to aid in short runway landings in mountainous areas, and with the Toronto-based City Express, which helped to establish the viability of STOL commuter service based on the Dash 7.[44]

Creating New Markets

The external benefits that resulted from de Havilland Canada's work on STOL aircraft went beyond the direct linkages that were formed, resulting in benefits for other participants in STOL aviation in North America. De Havilland Canada has invested heavily in promoting regulation changes in the United States that would open the market for its STOL commuter planes. This involved contributing to a network of STOL proponents, the generation of norms and standards, and a pool of collective knowledge necessary for the creation of a new market.[45]

In 1966, de Havilland Canada had been a major participant in Metro 66 in New York City. This two-day demonstration involved hundreds of take offs and landings from eight downtown locations, clearly showing that such operations were feasible. As part of its activities to promote the Dash 7, de Havilland Canada was instrumental in persuading the American Federal Aviation Administration (FAA) to amend and clarify regulations about such things as runway size and approach angles. The old rules had been written for older technology and had proven unduly restrictive to entry into STOL aviation by builders and operators. Further, de Havilland Canada provided six Twin Otters, equipped with specially prepared braking and avionics systems, for the Airtransit pilot project between Montreal and Ottawa.

Junction Effects: Strong and Persistent Complementarities with Pratt & Whitney Canada

There is a continuum in the relationship between de Havilland Canada and Pratt & Whitney Canada since their creation as businesses in small planes and small aircraft engines respectively. From 1928 to the 1940s, de Havilland Canada assembled (and sometimes built) Moths, and Pratt & Whitney Canada assembled and serviced the Wasp and Hornet piston engines that powered them. After World War II, de Havilland Canada was the first to use war surplus Wasp engines, overhauled by Pratt & Whitney Canada, for its piston Beaver and Otter. In the early 1950s, de Havilland Canada used the Wasp piston engines that Pratt & Whitney Canada had begun to manufacture directly. Both firms made the switch to turbines simultaneously — the de Havilland Canada Turbo Beaver and Otter and the Pratt & Whitney Canada PT6 and variants. Later, Dash 7s and 8s were matched with further PT6 variants, as well as a newer generation of turbine, the PW100s.

The systematic and persistent complementarities of these two firms' main products were instrumental in promoting the acceptance of their combined product and the development of each firm's technical capabilities. Furthermore, the success of each of their innovations reinforced the other, with dynamic effects resulting from their close complementarities.

James Young, president of Pratt & Whitney Canada, convinced Phil Garratt, head of de Havilland Canada, to use overhauled surplus Wasp Junior piston engines rather than the British Gypsy Queen for the Beaver. The availability of the Wasp engines for this purpose was contingent on Pratt & Whitney Canada getting approval for their air worthiness from the Canadian government and from its parent in Hartford. The fact that approval was given was fortuitous for both Pratt & Whitney Canada and de Havilland Canada, as the success and reliability of the Wasp-powered Beaver helped the reputations and financial stability of the two companies.[46]

De Havilland Canada's airframes and Pratt & Whitney Canada's engines continued to be closely complementary after the Beaver. In order to build the Otter, with a 3,000-pound payload (three times that of the Beaver), de Havilland Canada was at first faced with the prospect of having to use two engines. Two piston engines would have been much too heavy. Pratt & Whitney Canada was willing to produce a geared version of the Wasp H that would make the single engine Otter feasible. The suggestion for this modification came from Fred Buller of de Havilland Canada, who had heard that such an engine had been built in Australia.[47]

During the pre-production development of the PT6, de Havilland Canada built a flying test bed specifically for the PT6 and installed two of the new turbine engines on its own Otter that it used for STOL research. Two PT6 turbines weighed less than the single piston engine used on the Otter, thus greatly improving the performance of the Twin Otter in terms of speed, payload, and operating costs. De Havilland Canada was also fortunate in that the Twin Otter started production just as the demand for small turboprop commuter planes was increasing.[48]

Downstream Effects for Users

The symbiotic linkage of de Havilland Canada and Pratt & Whitney Canada went beyond producing benefits for these two firms and resulted in important externalities.

The Canadian-designed and -built PT6 turbine which powers the Twin Otter is also responsible for the rejuvenation of the Beaver, which has found new application as the Turbo-Beaver. A number of operators of the piston-powered version are finding it advantageous to trade in their old airplanes (often for more money than they cost in the first place) on the new turbine model. The Ontario and Manitoba governments are among the customers for the Turbo-Beaver and they are likely to convert their entire fleets eventually.[49]

The externalities include the extra value and performance gained by operators of the old Beavers (whether they converted or traded them in) and the work generated by the conversions.

Appraisal

The level of technological accumulation was affected by the foreign owner, its strategy and the status of the relationship. Autonomy and complementarity were beneficial while a branch plant relationship with a parent producing substitute products was detrimental. But the extent of backward linkages is due to the design and production of whole systems and is not affected by the changing patterns of ownership *per se*. Also, the degree of forward linkages appears related to the presence — or lack of — astute strategic management at the local or international level and not to foreign or domestic ownership.

CANADAIR'S DEVELOPMENT OF TECHNOLOGICAL CAPABILITY

CANADAIR (PREVIOUSLY CANADIAN VICKERS AIRCRAFT DIVISION) has been in and out of foreign and domestic ownership, as well as Canadian government control. From very early in its history, the firm has had to rely on in-house technical development or technology transfer from outside its corporate entity. It thus offers an interesting comparison with the two preceding subsidiaries, which had various degrees of success in transferring technology from the parent firms.

Once again, any advances in acquiring a technological capability and securing supporting technological linkages appear to be affected mainly by factors other than foreign or domestic ownership. Some of these factors are: the strategic decision in the 1950s to develop a total design and manufacturing capability of complete systems; an early decision to become a commercial aircraft manufacturer; a failed attempt to enter the commercial freight and airline field (which had irreversible consequences);[50] subsequent extreme dependence on defence procurement; management skills of the parent or subsidiary; a limited capacity to focus on and specialize in a given technological area; limited opportunities to produce cumulative runs large enough to realize benefit from learning by doing; positioning early or late in the technology life cycle; a capacity to retain the core skills and experience of the workforce or large turnovers in personnel; combinations of the downturns in the defence and commercial markets in the 1970s; and audacity and risk-proneness in compressing the time of the Challenger's development.[51] These factors interact with the status of the subsidiary and its past reliance on production licenses for aircraft and components. Production licenses tend to pass on established designs and existing technology, with little involvement in applied research, much less basic research.

Little Technology Transfer from Parent Firm and Affiliates

Under British Vickers, technology from the United Kingdom seemed to flow freely, although the parent firm, like its Canadian subsidiary, was involved in both shipbuilding and aircraft. Under the ownership of General Dynamics, there was very little technology transfer between parent and subsidiary, and what there was involved production rather than design capabilities. However, there was a free flow of personnel, in particular engineering personnel. Much of the technology was developed in-house. In the early 1950s, many process and management skills were acquired through the hiring of ex-Boeing people, who brought with them the basic rules of cost control and production and employment planning. On the other hand, Canadair loaned many engineers to Boeing for the 727 and 767 projects.

The technology acquired from General Dynamics was not particularly valuable. In 1957 for example, another subsidiary of General Dynamics, Convair, discontinued production of the CV-440 airliner. The jigs and tools from this project were transferred to Canadair, and out of this came the Cosmopolitan CL-66.[52] Also, this type of transfer was not much more beneficial than that which Canadair, on its own, had been able to obtain from the independent firm Douglas.

When the government bought Canadair, the firm continued to rely for technology mainly on its own resources. The example of the Challenger is a case in point.

> "Bill Lear had given the marketing impetus for the Challenger but the layouts he provided were inadequate and incomplete; they were never used. Instead

> Canadair proceeded to size the aircraft based on the anticipated need for comfort on transcontinental travel of the business executive, future adaptation of the aircraft to airline use, and the airframe strength required to allow freighter operation. An aerodynamically efficient wing was developed by Canadair and the aircraft was designed to fully meet the United States Federal Aviation requirements — the same that the Boeing 757 had to meet. Those two aircraft built at approximately the same time, were the first commercial aircraft to meet the new more stringent safety and noise requirements and brought about a new approach to airframe damage tolerance testing.
>
> "The Challenger flew its maiden flight in 1978 and was the first aircraft to fly with a 'super critical wing'. It was followed by the Cessna Citation III in 1982, the Airbus A310 in 1983. Boeing and McDonald Douglas are planning to fly models with super critical wings in 1992.
>
> "Another example of reliance on its own internal resources was the development of the surveillance system product line. Started after the cancellation in 1959 of the Avro Arrow, which left the missile group without a project, a requirement for pilotless airborne surveillance vehicle was identified. This led to the development and production of the CL-89 system. The development was funded equally by Canada, the United Kingdom and Germany. A follow on system, the CL-289 with greater range and more payload capability, is presently in production. The Cl-227, a remotely piloted vehicle, using propeller technology developed for the CL-84 V-STOL aircraft, is undergoing evaluation for the U.S. Navy.
>
> "Relying on internal resources is likely to remain to some extent under Canadair's present owner Bombardier. CAD/CAM, already acquired by Canadair on the Challenger program, found its first use and refinement on the Airbus programme."[53]

But other Bombardier aircraft affiliates will no doubt supply technology in the future as the firm decides to have each affiliate specialize and become a centre of excellence in a given field: Short Brothers in materials; LearJet in testing and cabin outfitting; and Canadair in large, heavy machining. This may result in future technology transfer and the capabilities developed in other types of transportation production can provide opportunities for exchanges between affiliates. The know-how transfer is certainly already apparent at the level of management processes, divisional responsibility and cost control, personnel management and marketing and strategic planning, especially integrating product design, operations, cost control and marketing focus. Bombardier instituted six autonomous divisions (Waterbomber, Challenger, Regional Jet, Surveillance systems, Defence, and Manufacturing), as well as other managerial innovations. But on the whole, Canadair still remains reliant on in-house developments.

Canadair's most important technology transfers have not been from its parent company (British Vickers, General Dynamics, or Bombardier), but from outside independent firms. For instance, in 1945, Canadair sent its factory manager to the Douglas Aircraft Co. in California to learn about the production methods Douglas was using in building its DC-3 transport and transferring to its new DC-4. Canadair bought all of the tooling, parts and work-in-progress for the DC-3 and its military version, the C-47. Canadair was then able to purchase several hundred surplus C-47s, convert them to civilian use, and resell them. Because the DC-3 was one of the most successful airplanes in aviation history (over 13,000 built), Canadair, with all of the original tooling, was in an excellent position to carry out overhaul, repair and modification work on them.

In a different context, when Electric Boat (later to become General Dynamics) took over Canadair in the 1947, it hired an experienced aircraft executive (from Boeing) to head Canadair. He came with a number of other ex-Boeing managers to transfer many of the manufacturing procedures from that company. In subsequent years licensed production of military aircraft from companies such as North American Aviation, Lockheed and Northrop gave access to technological innovations in manufacturing as did the manufacturing of airframe components under contract. Recently, Aerospatiale and British Aerospace have supplied a funnel for technological learning in CAD-CAM and aluminium-lithium. In return, these firms gain from Canadair in chemical milling and machining.

The fact that the private owners of Canadian Vickers/Canadair were never primarily in the aircraft business but in other industries made the firm essentially technologically dependent on in-house developments and transfers from other independent firms through technological alliances. It remains the case to this day that Canadair (under domestic ownership), apart from developing its own technology, uses alternative modes of technology transfer (such as contracts to build aircraft components) to that of a parent.

Diseconomies of Scope, Turnover and Spin-Offs

In the process of accumulating technological capability, a common strategy used by aircraft firms is to search for possible economies of scope. To this end, Canadair carefully plans for machinery to be usable on a variety of jobs, and reduces the number of model-dedicated jigs and fixtures to a minimum. In this respect, when its commercial transition in the mid-1950s aborted and the defence market collapsed in the early 1970s, Canadair attempted to keep its core engineering design staff occupied with whatever design contract activity it could find. Such dispersal of effort was partly encouraged by the first two non-aircraft owners (British Vickers and General Dynamics) and the government under its tenure. "Diversification" was a buzz word and business solution at the time. But the extent of the dispersal of effort by Canadair may be explained by more than the ownership factor.

For decades, Canadair has had a combined involvement in defence work and civil aircraft, which is not unusual for aircraft manufacturers, but has always had a heavier dependence on defence than Pratt & Whitney Canada. Canadair also combined transport planes with utility planes (such as the waterbombers and the CL84 V/STOL aircraft). As with most aircraft manufacturers, Canadair combined assembly, overhaul, repair, manufacturing, and design. As such, this variety of work is customary.

From its inception, it was always intended that Canadair design and build commercial aircraft. This required perseverance. Indeed, it was because it was so difficult to achieve this goal that Montreal reaped a number of external benefits. Canada, too, benefited both in terms of trained personnel and spin-offs. Some activities at the frontier of Canadair's technological capability and mandate gave rise to spin-offs. Up until the 1980s Canadair tried to retain its skills and technological know-how by finding other work beyond its immediate scope. It first acquired an off-road manufacturer (Flextrac Nodwell) and then spun off these activities. It set up specialized divisions which it later spun off (e.g. Canarch, an architectural design firm). Ontario's Urban Transport Development Corporation (UTDC) and Metrocan's development of SkyTrain can be seen partly as spin-offs of Canadair's activities. However, Canadair does have an explicit procurement policy in order to share the work with vendors. In fields where Canadair does not want to do the manufacturing, like electronics, it may design the product itself and then contract out the production. If the firm is already proficient in the field, like Marconi for example, it will need little assistance, but a small firm will need more. A firm like Edco in Vancouver, for instance, benefited substantially from Canadair's contracts.

Even in the most successful aircraft firms, such as Boeing, employment is like an accordion, and Canadair is no exception. There is also a constant movement of tool makers, engineers, designers and management personnel between aircraft firms. Many engineers have gone from Canadair to Boeing as it increased its employment. Nonetheless, Canadair managed to keep the core of its engineering design team from the 1950s through the recessions of the 1970s — even though this team at one point dwindled to a few hundred — and retained considerable aircraft experience and savvy in the process. To accomplish this, Canadair has used a number of monetary and non-monetary incentives.

Domestic Junction Effects and Supplier Linkages

The circumstances for potential junction effects between Canadair and Pratt & Whitney Canada were less favourable and fewer than those that had existed between the latter and de Havilland Canada. For example, Pratt & Whitney Canada's engines were not always good matches to Canadair's airframes. Where junction effects did exist, they were not fully exploited. In the case of the CL-41 Tutor, Pratt & Whitney JT12s were only used in the prototypes. This was the engine designed as a training exercise by the Pratt & Whitney Canada team that went to Hartford in 1957 to prepare for the PT6 project, and which was soon after put into production by the American parent.

However, when the CL-41 went into production, the Canadian Government awarded a contract to Orenda to build General Electric engines (Pratt & Whitney Canada did not have a suitable power plant at that time). In the case of the CL-215 Waterbomber, the original was powered by Pratt & Whitney radial piston engines, designed and built in the United States for World War II bombers.[54]

External linkages were present in both instances; Pratt & Whitney Canada had designed — but not built — the JT12 and was the sales and service representative for the CL-215 engines. A good complementarity arose in the case of the Turbo version of the waterbomber, the CL-215T, as suitable PW100 variants were available and these greatly increased the performance of that plane.

A full junction effect never materialized between Canadair and Pratt & Whitney Canada, but the possibility for one had been greater with Orenda, whose engines were often better matches to Canadair's airframes. Between 1949 and 1958, Canadair built more than 1,800 Sabre jet fighters under license from North American Aviation. The program resulted in an early complementary linkage when several versions of the Sabre were built using different models of engines built by Orenda. This was still relatively early in jet aviation technology, but the potential of this linkage and its technological trajectory might have evolved differently had Orenda not been caught up in the Arrow program. Orenda's original design efforts went into the Iroquois engine program for the Arrow. After the demise of Avro, Orenda emerged as part of Hawker Siddeley Canada, and the engines that it supplied for the CL-41 Tutor were built under license from General Electric. More recently with the Challenger and the Regional Jet, a domestic linkage with Pratt & Whitney Canada will not materialize unless the latter moves into production of much higher powered engines (e.g. 14,000 pounds) — which are now made in Hartford.

Canadair's suppliers for its innovative efforts have been more diverse and changing than for the other innovators in the Canadian aircraft industry. No doubt the dispersion of products and technological endeavours induces the dispersion of suppliers. On the whole, Canadair has had fewer Canadian suppliers for its innovative activity than Pratt & Whitney Canada, but there was an attempted on-going collaboration with Orenda engines (for the Sabre, the CF5 Tactical Fighter, and the Tutor). In the engine field, there is now an established relationship with Pratt & Whitney Canada for the overhaul of the waterbombers. For landing gears and doors, a long working relationship has been in place with Jarry Hydraulics and Heroux. With the swing tail modification of troop carriers into air cargo planes, Canadair alone was early in the growing market niche. However, this modest but promising innovation aborted when an offset for a large military purchase between Canada and the United States could not be negotiated.

With the Challenger program, however, the direction has changed. The design and manufacture of a new total system and commercial model offered new opportunities which had not existed since the mid-1960s with the CL-215 Amphibian. For the Challenger program, the government required that component supply be spread throughout the country and that it meet Canadian and provincial content requirements. An outside production department was set up to find suppliers in Canada. The Canadian content is estimated at 50 percent and most of the original suppliers remain. When the power unit, the avionics and the nacelle must be sourced outside the country, there is a limit to supplier network development. Even in materials, while there are some casting and forging suppliers in Canada, there are very few others.

Exploitation of User Linkages

Up to the early seventies, Canadair's dominant linkages with users had been with defence agencies and government, as its past has been dominated by defence contracts, licences and subcontracts. Such cost-plus contracts are very demanding on the performance end, but they also have their disadvantages. Custom work to satisfy the demands of a sophisticated defence client does not induce a firm actively to seek out user input to the extent that is necessary in the commercial field. Although regular annual user conferences have been a tradition at Canadair since the Amphibian (CL-215) in the 1970s, it is only in the commercial field that they have long-lasting benefits to the firm's performance. As late as 1981, Canadair held a user conference for the swing tail, a late 1950s model. There are two notable cases of continuous user feedback on a Canadair innovation. In the case of the CL-215 waterbomber, forest fire fighters from Quebec, Manitoba, France, Spain, Greece, Italy and Yougoslavia regularly fed back technical information that went into the improvement of this aircraft. In the case of the Challenger, user feedback comes from the corporations that own the planes.

Status: From a Diversified Defence Contract Firm to a World Mandate in Aircraft

Aircraft manufacturing has never been the main area of interest of either the foreign or the domestic parent of Canadair. "By 1944, Canadian Vickers ha(d) become so heavily involved with wartime shipbuilding and repair programs it became obvious that the company could not run both ship and aircraft operations efficiently."[35]

To all intents and purposes, Canadian Vickers (soon to become Canadair) had been, and had behaved as, a domestic firm since 1927. The problem then was not one of foreign control, but rather of domestic control by a firm mainly involved in another industry: shipbuilding. Curiously, this situation reappeared after the Canadian government reprivatized and sold Canadair to Electric Boat (soon to become a division of General Dynamics). Once again, the aircraft firm would simply become one element in a firm increasingly dedicated to another industry (nuclear submarines and building suppliers).

General Dynamics, a major diversified but defence-oriented corporation, ran Canadair largely as an autonomous branch operation as part of the postwar

Canada-U.S. Defence sharing agreement. In fact, however, General Dynamics gave contracts to Canadair but no new development projects. Under this arrangement, General Dynamics subcontracted some of the empennage, the vertical fins, and carry-through fittings and pivots for its F-111 fighter to Canadair, which induced the latter to start up its massive machining capability. Canadair also produced ball valves and other submarine components under contract to the Electric Boat Division of General Dynamics.[56] But aside from that of its subsidiary Convair, General Dynamics transferred little appropriate technology to Canadair to help it attain its strategic intent to become a commercial aircraft manufacturer. Moreover, General Dynamics once told Canadair to get out of an area it was also working in: the nuclear field. In retrospect, it seems as if the management of General Dynamics paid very little attention to Canadair, although most or all of the profits were ploughed back into the company. Canadair did not suffer from its parent blocking its development, but rather from lack of attention.

The takeover of Canadair by the Canadian Government produced mixed results. At first, there was welcome relief after the stagnation of its time under General Dynamics, and there was some inducement to focus the firm. However, Crown control was, on the one hand, too cumbersome for Canadair (slowing down the decision making process) and, on the other, too lax (development costs rose out of control). Nor did the government seek or call in a new team of executives to lead the firm — as is the usual practice after a private takeover.

Canadair's role with Bombardier holds much more promise. There appears to be sufficient autonomy for Canadair's management to pursue development programs under its own directives, but not without accountability to a firm with a strong integrated design, marketing and financial capability. Each division is accountable for its own bottom line. With the Challenger and Regional Jet programs, the subsidiary is not in any way competing with its parent, and thus Canadair's product mandates are strong. Bombardier further supported Canadair by purchasing Short Brothers of Northern Ireland, thus transforming a competitor into an affiliate,[57] and later LearJet, a firm that produces the full range of executive jet models and has a strong reputation, with hundreds of potential repeat customers. By planning to develop each of its three subsidiaries into a centre of manufacturing excellence, Canadair will probably specialize in machining.

Appraisal

The lack of autonomy from its previous parents, lack of clear world product mandate, and the absence of recent technology transfer from the parent and its affiliates all contributed to making Canadair reliant on production contracts and licences, mainly for technological innovation in manufacturing, even though in the years from 1951 to 1953 it had developed a total design and manufacturing capability. However, in our opinion, it was not primarily

Canadair's subsidiary status *per se* but other factors that were, until the recent success in the total design and manufacutring of a commercial airplane, the main cause for the absence of strong backward and forward linkages.

GOVERNMENT POLICY ON THE AIRCRAFT INDUSTRY AND FOREIGN SUBSIDIARIES

NO AIRCRAFT MANUFACTURING FIRM in the world functions without government support. Although governments do not often reveal the extent of their support, some incomplete data is available. In the eight major manufacturing countries, R&D in the aircraft industry is supported by public funds to the extent of 20 percent to 70 percent in the United States;[58] 50 percent to 70 percent in Japan;[59] and more than 70 percent - 80 percent in Italy,[60] In France, Germany, and the United Kingdom between 50 percent and 70 percent of aircraft R&D is supported by government funding.[61] The Canadian government assists aircraft projects through the Defence Industry Productivity Program (DIPP)of the Department of Industry, Science and Technology. The program funds up to 50 percent of R&D for new projects, up to 35 percent for derivatives, and up to 50 percent of tooling for smaller firms. These funds are repayable when the projects become profitable.[62] Since the 1980s, when the practice of Memoranda of Understanding[63] was instituted to specify the firm's business plan with respect to R&D and the level of government participation, the goal has been to reduce public participation.

The level of government participation is difficult to estimate. Military and commercial R&D are too often intertwined. Military contracts, including R&D, are fully financed on a cost-plus basis. The share of military use of aircraft development varies in the different countries. Canada, for instance, has little or no direct defence development of whole systems, and only becomes involved in sub-system or parts development through defence procurement sharing with the United States. Beyond defence programs, many countries get involved in the equity of state-owned corporations and/or bail out of firms on the brink of bankruptcy. Aircraft manufacturing firms that contribute to national strategic goals are just not allowed to go under. The American government approved the merger of McDonnell and Douglas in 1967 and guaranteed a $75 million loan, and the collapse of Lockheed Aircraft Corporation was only averted by a Federal loan guarantee of $250 million in 1971. France and Italy have major equity participation in state-owned corporations and have explicitly favoured domestically owned firms over foreign ones. Holland invested $1 billion to save Fokker. Canada put $1.1 billion into Canadair and $845 million into de Havilland Canada during the time of their public ownership.

Government policy for the commercial aircraft industry takes many forms, from supply-side to demand-side instruments.[64] Because of the close inter-dependence of the military and commercial activities of aircraft manufacturers in terms of technological frontiers and opportunities, related learning curves, technological capabilities and equipment, these firms are seldom allowed to go under, and are constantly spurred on by governments to further technological achievements.

Although it is difficult to estimate public support for these firms, countries with a heavy independent defence weapons development program and a steady policy of state ownership and/or "chosen instruments" support their commercial aircraft firms at higher levels. In aeronautics, the competition between countries and states is not conducted on a level playing field. Because of the interdependence of defence and military functions within the aircraft industry, unless there was a state of generalized disarmament and a subsequent mutual suppression of national subsidies, it is unlikely that competition among aircraft manufacturing firms will ever be perfect. In this respect, the Canadian government is not among those countries that proportionately provide the most support to their industry.

Competition in the aircraft industry cannot be evaluated without considering government support, in particular for R&D. But the support must be understood in relation to overall policy. Somewhere between 1920 and 1940, an infant industry policy was established for the aircraft industry. By the 1940s, C.D. Howe made it explicit: he would use defence procurement and the defence production sharing agreement with the United States and the United Kingdom to build a Canadian aircraft industry that would emerge from the War able to compete on its own feet. Canada was not too late an entrant into the field, so the technological gap it had to bridge was quite narrow. Also, Canada offered a substantial domestic market base with its own special requirements and cooperative defence production with the allies offered excellent opportunities to acquire leading edge technology. The infant industry policy was seen as long term, requiring decades to set up a viable aircraft industry (as the original framers had specified).[65]

In 1990, Canadian public policies still bear the mark of this original policy. After the Avro Arrow fiasco in 1959, the Canadian government began to disengage from an across-the-board support of all aircraft projects. Specific technological trajectories (such as STOL aircraft), market segments (such as bush planes, long-distance executive jets, and commuter airplanes), and niches (such as the waterbomber) were given preference for government support. Late in 1972, the government began to provide funds for design, development and production of new airplanes and engines.[66] In the 1980s, further efforts were made to reduce the government support for R&D to 50 percent or less. But even in 1990, the goal of public servants in the aircraft branch at the Department of Industry, Science and Technology, has been to sustain and develop the existence of the industry in Canada. Industrial preparedness in this industry is still related to strategic and defence policy. In other words, all sorts of policy instruments are used to pursue this general goal.

Within this intent to sustain the industry as a whole, no explicit preferences are given to regions or firms, whether due to ownership or size.[67] Industry support is accompanied by no explicit regional policy goals. Government officials tend to avoid duplication of projects and they explicitly encourage collaboration between firms within the country in system development. In the last decade, joint supplier development committees have been set up to accompany the major DIPP programs in order to favour the technological development of Canadian suppliers. But applications for government support are judged on a project-by-project basis using criteria of the project's technological merits, and the firm's own capabilities, commitment and business plan, requirements for assistance, and eventual capacity to repay the grants. Domestic or foreign ownership of the firm is, in principle, irrelevant. Autonomy and world product mandates are preferred for foreign subsidiaries, and in this respect there resides a characteristic of an infant industry policy for aircraft: foreign subsidiaries have always been a *de facto* central instrument of this policy.

We will now examine the government's policy towards these three Canadian aircraft manufacturing firms in relation to two main instruments: one supply-side (support of R&D under the Defence Industry Productivity Program grants) and one demand-side (government procurement).

Financial support is given in the form of R&D grants for new development projects, which are repayable if and when the projects become profitable. Although not all these projects involve the military, it remains significant that they are awarded under reference to the defence industry's productivity. They are made to counterbalance the Pentagon's 100 percent cost-plus defence contracting. Pratt & Whitney Canada has almost always received the largest amounts, but has also started to repay over $100 million. The firm claims to invest between 23 percent and 27 percent of its sales in R&D, and that two thirds of their sales in 1989 came from products that were not in existence in 1983 (although the PT6 generation still accounts for the majority of their business). Before 1983 and the practice of memoranda of understanding (MOUs), the level of financing was 50 percent, but has since been pushed down to between 25 percent and 35 percent.[60]

De Havilland Canada has received lesser sums, mainly for its STOL projects. Under Boeing's four-year tenure, de Havilland Canada received only modest amounts, as most projects were not new and Boeing was seen as able to pay. Because the firm has not had any profit on these projects, it has not started to repay the grants. Canadair has also been a major recipient of DIPP grants, mainly because it has traditionally been more involved in defence sub-contracting, maintenance and overhaul projects.

One aspect worth mentioning is that the government will support complementary endeavours by different firms. For instance, it simultaneously supported de Havilland Canada for DASH projects and Pratt & Whitney Canada for the appropriate engine development — the PT6A-50. In 1985 it supported the Bell Helicopter project for $165 million and Pratt & Whitney Canada for $100 million for engine development.

TABLE 1

DEFENCE INDUSTRIAL PRODUCTIVITY PROGRAM GRANTS

	PRATT&WHITNEY	DEHAVILLAND	CANADAIR
1981-2	$ 37,198,885	$ 6,232,296	$ 40,483,337
1982-3	38,980,338	3,188,259	14,037,791
1983-4	52,490,230	2,355,661	4,746,159
1984-5	51,767,898	607,486	9,337,299
1985-6	56,942,396	282,825	18,828,877
1986-7	70,023,792	19,626,216	12,132,285
1987-8	56,930,686	3,255,998	14,364,974
1988-9	60,175,554	3,176,682	42,590,053

SOURCE: Public Accounts, 1981-89

Tax incentives are another form of financial support. But only Pratt & Whitney Canada has benefited because this firm is the only one that has regularly made profits. Those sums amount to about half of the DIPP grants.

As the Canadian forces do not develop their own weapons systems, government purchases represent a much smaller share of aircraft manufacturers' sales than in the United States. For Pratt & Whitney Canada defence projects today represent between 20 percent and 30 percent of their business — depending on the estimates.

De Havilland Canada has recently had little support from government purchases (two Dash 8 and four trainers), although in the past Transport Canada put a lot of funds into the development of STOL ports and experiments, and the Ontario Provincial Air Service was key, as a lead user, in helping its earlier bush plane successes. For commuter airplanes, there is little domestic market base and de Havilland Canada has received little direct purchasing support from the government. Canadair, on the other hand, has regularly benefited from government purchases, both on the defence and civil side. The case of the F-18 maintenance contract is well-known in the defence field, and the demands of the forest services for the different models of the waterbomber are also important.

Canadian aircraft manufacturers cannot expect technology transfer from the domestic defence establishment, and they will sometimes be barred from transfer of like technology from the Pentagon.[69] However the National Research Council, principally through its aeronautical establishment, offers a source of basic and applied research that assists firms in keeping abreast of a moving technological frontier. The NRC has assisted firms with a slow-speed wind tunnel, turbine development, noise reduction, materials, firefighting waterbomber design, and STOL technology.

In summary, Canadian government support to the aircraft industry is necessarily weak from the demand side because Canada does not develop its

TABLE 2

FEDERAL SUPPLY CONTRACTING[1] FROM THE THREE FIRMS ($ MILLIONS)

YEAR	PWC	RANK#	DHC	RANK#	CANADAIR[2]	RANK#
1984-5	61.1	17	n/a	>20	142.7	6
1985-6	n/a	>20	94.6	10	297.9	1
1986-7	230.0	3	n/a	>20	181.2	6
1987-8	121.2	6	n/a	>20	404.0	2

1. Contracts include goods and related services, including guided missiles, aircraft, airframe structural components, consulting services and scientific research. (Source of definition: Supply & Services Canada Contracting Statistics Fiscal Years 85-86, 86-87).

2. Officials from Canadair only accounted for more limited purchases from the government: $46.7 million in 1984-5, $164.8 million in 1985-6, $80.7 million in 1986-7, and $68.7 million in 1987-8. In order to maintain a basis of comparison between firms, however, we presented the government data.

SOURCE: Annual Reports, Supply & Services
n/a = not available

own weapons systems, and is relatively weak on the supply side in comparison with other countries because no defence-spurred research encourages R&D on the technological frontier, and grants only account for between one-third and one-half of expenditures. This makes aircraft manufacturers all the more dependent on foreign firms, either through their Canadian subsidiaries or through joint ventures and technological alliances.

CONCLUSION

WITHIN THE INFANT INDUSTRY POLICY to develop and maintain a Canadian aircraft manufacturing industry in an open economy, tariffs had to be avoided because the market is mainly international, and domestic sales are too small. Although subsidies are used on the basis of performance requirements (especially with respect to R&D), foreign subsidiaries have been welcome because they were viewed as bringing more direct access to recent technology. But, as we have seen, this is not always the case. It has proven to be true with Pratt & Whitney Canada and de Havilland Canada under de Havilland in the United Kingdom (and later under Boeing), but not for de Havilland Canada under Hawker Siddeley, nor for Canadian Vickers under Vickers (U.K.) or General Dynamics. Autonomy of local management and an evolving world mandate have always been sought by the government in instances of changes in ownership. In the 1990s, with the possible sale of de Havilland Canada by Boeing to A.T.R., a new issue arose: Does it matter if the owners are foreign state-owned enterprises?

Although in the 1990s the public policy discourse in North America has been explicitly "laissez faire", in practice the French and Italian governments — who own A.T.R. — support their aircraft industries much more than Canada does (this would also largely be the case if a Japanese firm were bidding).[70]

During World War II, C.D. Howe's industrial mobilization and coordination was an explicit industrial policy, and in the case of the aircraft industry, an infant industry policy. Whether or not it was worth the public cost is one issue; it remains that Canada is the fifth ranking commercial aircraft and engine exporter in the world, and all indicators point to its comparative advantage in the small aircraft market segments. Such a competitive achievement may, in hindsight, justify this infant industry policy. Without the massive industrial mobilization during World War II under C.D. Howe, it is doubtful whether the Canadian aircraft industry would ever have reached its present stature, or the threshold level of physical capital and intangible technological assets necessary to compete in the world market. Even if the present context of public policy is not interventionist, the present state of the industry is a legacy of an interventionist phase. Since C.D. Howe's time, the policy has been made more liberal by successive degrees. But if Canada wants to maintain an aircraft industry, it would be nonsensical to give it even less support than its competitors on the world market receive, simply on the basis of unilateral liberalism.

Within this policy, can foreign direct investment be a useful strategy and complement to international strategic alliances in order to gain access to technology and markets, in the aircraft industry and elsewhere? It is difficult to generalize about other industries because different appropriation regimes and levels of technological uncertainties prevail. It is even difficult for us to generalize about smaller firms in the same industry. We have only compared three of the dozen large firms in the Canadian aircraft industry. On balance, however, three tentative conclusions can be drawn.

First, entry of a foreign firm in the early stages of a technology cycle is more likely to lead to technological build-up if the following criteria are fulfilled:[71]

i) encouragement by the foreign headquarters to service the domestic market and its specific requirements as well
ii) a simultaneous world mandate
iii) allowance for this mandate to evolve specifically toward whole systems and a full design capability
iv) autonomy in management
v) two-way technology transfer.

At the early stage of the technology life cycle, foreign ownership may be preferable to foreign licensing as a means of access to technology, but does not enable a firm to do without international strategic alliances — especially in the aircraft industry. These are, however, necessary but not sufficient conditions for the build-up of technological capability.

Foreign ownership is only indirectly important to external linkages. In terms of backward linkages, the opportunity to design and manufacture whole systems in the commercial field over a long period of time is, it seems, the key variable — whether for a foreign subsidiary or a domestically owned firm.

Because proximity is important in creative technical transactions, some — but not all — of these backward linkages will be domestic. Therefore, if domestic benefits are to be reaped, foreign firms must be induced to allow their subsidiaries to design whole systems. In the case of foreign linkages, some domestic market base is useful, but the aircraft market is essentially international. Foreign ownership can give better access to this market if a world product mandate is given to the Canadian subsidiary.

Second, takeovers by firms (either foreign or domestic) that have rival substitute models and designs should be looked at closely for their potential anti-competitive aspects, as these can lead to an unwarranted transfer of rents, dissipation of assets, and reduced product diversity or price competition. As there are no international regulatory bodies in this area, but any international anti-competitive acquisition will also affect Canada, the Competition Act must be used. It is not impossible that some rival firms with similar products may decide to develop (with the acquired subsidiary) some complementarities, joint projects, and synergies — but this must be ensured through the performance requirements of R&D subsidies.

Third, takeovers by firms that are very diversified (either foreign or domestic) and which do not give priority to the aircraft industry and are unlikely to transfer leading-edge technology to the subsidiary, are problematic as they do not address the issue of acquisition of new technology, which must then be resolved through other means. In particular, takeovers by firms mainly in the defence field are less likely to lead to backward linkages. The issues of access to foreign markets and world product mandates can be addressed by the Investment Canada review process. The problem of access to new technology has to be addressed on the basis of performance requirements, when and if the subsidiary applies for R&D project support. On the other hand, labour externalities and spin-off firms are essentially determined by local and headquarters management practices, and foreign ownership is largely irrelevant.

In summarizing this comparative analysis, it is impossible to ascribe to any single variable a positive technological performance and external benefits to Canadian industry. Furthermore, many of the key variables are clearly independent from foreign ownership and have no relationship to policy. Most of the key variables depend on management strategies regarding technological, marketing, operations, financial, and labour relations practices. Combinations of elements including historical circumstances, head office behaviour, local management assets, market focus, government support, and the irreversible effects of historical accidents must be taken into account to explain the variations of technological performance and externalities of foreign aircraft subsidiaries. In the preceding discussion, we have considered only a few of the variables related to foreign investment issues. It would be presumptuous to think certain of these variables could be manipulated to produce a better performance. For instance, it is not realistic to attempt to reproduce the Pratt & Whitney Canada success story.[72] At best, inducing a favourable situation may increase the possibility of success, but success rests largely in the hands of management.

Entry of a subsidiary early in a technological life cycle seems to create a more favourable technological and market environment for an autonomous and evolving mandate for a foreign subsidiary. This can eventually lead to significant technological accumulation, including threshold leaps and transformation of intangible assets. The early entry of a subsidiary in the technological life cycle can also promote technological competition at the edge of the technological frontier. In contrast, late entry, as in the case of some industrial chemicals in Canada, implies a standardized and stabilized product and process design, with well-defined tasks and a necessarily well-specified narrow mandate, even in the case of relative autonomy.

In the early stages of a technological life cycle, a foreign subsidiary of a leading edge firm may have a technological advantage over an independent domestic firm, if the foreign parent is willing and eager to engage in reciprocal technology transfer. We recommend that, if Canada hopes to be part of technological development thirty years down the road, we begin now to attract foreign subsidiaries (with the criteria stated above) in areas such as bio-engineering, superconducting materials, micro-processors, and super-computers from technologically leading countries like Japan, Germany, and the United States. In the early stages of a technology life cycle foreign subsidiaries may assist in postponing premature lock-in to one technological version, help the country scan for technical alternatives, and find and learn the one most adapted to its factor allocation and existing assets.

Time of entry and relationship to the parent do not by themselves ensure good technological performance and benefits for the country. Some internal management factors can make or break the technological trajectory of the firm, even if the timing of entry and status of the subsidiary are favourable.

The conundrum for public policy in industrial technology development is that there are no single variables that the government can manipulate in order to ensure success. Furthermore, public policy must be set, just as technological management, in a contingency theory context where there is no such thing as a best practice. What may be good at one time for one firm in one context may be disastrous for another firm in another context, or even the same firm at another time. Similarly, what may be good policy at one point may be disastrous with another firm at another time.

Public goals must be clear and persistent, but individual policies must be assessed on the basis of the strategy and performance of the specific subsidiaries, and whether these are likely to help attain these goals. Some guidelines can be drawn from the above examples that might increase the possibility of success. Autonomy and the opportunity of an evolving mandate from the parent, and two-way technology flows seem to be necessary — but not sufficient — conditions for a successful experience. A parent firm that wants to service the domestic market and is keen on developing complementary skills and assets is necessary, and parent firms that view their products as rival substitutes should be avoided. But once these guidelines are followed, there is no guarantee of success because parent and local management skills are what can make — or break — a capability into a commercial success.

In the past, it seems that the federal government has paid more attention to structure and ownership, and less to local management leadership. Experience has shown in a costly fashion that any restructuring requires the search and choice, through management firms, of seasoned and proven aircraft management teams to lead these complex firms, which compete amid the uncertainties of the technological frontier, often having to create *ex nihilo* new markets.

Entry of subsidiaries at an early stage of a technology cycle offers better contextual chances for success derived from the benefits of autonomy and foreign ownership than entry at a later stage when the technology is relatively stabilized and standardized. Necessarily, an infant industry policy is a very long-term strategy, as is the policy towards the entry of a foreign firm through a subsidiary. It took 40 to 50 years for the Canadian aircraft industry to consolidate itself. In the aircraft industry, Canada is only now reaping benefits from the foreign subsidiaries that came into the country in the 1920s. This time horizon is, of course, longer than the political cycles of politicians. Some national consensus on the desirability of developing this new industry must be maintained over the years in order to ensure that such a policy would be effective.

ENDNOTES

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2. See for instance the "Gray Report" on Foreign Direct Investment (1971) or Gilmour, James and John Britton, "The Weakest Link", Science Council of Canada.
3. Even at the time of the Foreign Investment Review Agency, 98 percent of foreign direct investment was approved as bringing net benefits to Canada. The replacement of FIRA by Investment Canada shifted the focus from screening and control to that of promotion of foreign investment, but maintained a review function.
4. In a previous study, we found that the relative innovative contribution of foreign versus domestic firms was industry-specific (DeBresson and Murray, "Innovation in Canada", New Westminster, CRUST reprint, report to the Science Council of Canada, 1984). With the same data, we found that upstream and backward technological linkages were not clearly affected by foreign ownership. Generalizations are therefore hazardous.
5. We have not included A.V. Roe, a major systems and foreign subsidiary firm in our comparison. While the story of the demise of the Arrow is well-known, the earlier successes are less well known and would be interesting to examine in terms of the development of a domestic technological capability and linkages through foreign direct investment.

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38. Avmark Inc: Worldwide Aviation Marketing & Management Services newsletter, September 1990, page 14.
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46. Hotson, Op cit, pp. 102-5.
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48. Hiscocks, Op cit, pp. 49-50.
49. "Manufacturing Industry Review", *Canadian Aviation*, 39(12), 1966, p. 16.
50. In the late 1950s, Canadair developed a swing tail cargo version of a military transport (the Yukon or CL-44) plane with many letters of intent from commercial cargo operators, but the start up contract from the Materials Air Command of the U.S. Airforce did not materialize when an offset could not be negotiated. This design would have supplied a robust stretchable commercial design, Given the absent of an offset, the contract was given to Lockheed, which started a viable line of products with a competing design in this lucrative market segment.
51. Boeing has developed a number of planes without going through a prototype stage. This example may have had an influence on Canadair's planning decisions. Some of what had been learned in terms of cost control, production and manpower planning was learned from people who had been hired from Boeing in the early fifties, and Boeing is, at Canadair — as for other firms — the exemplar of a firm having successfully accomplished the transition from defence oriented production to essentially a commercial airplane manufacturer.

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60. According to a recent Italian law, commercial aircraft development is supported to the level of 70 percent to 80 percent, and international collaborations to 100 percent. This does not include government participation in the equity.
61. This estimate does not include government participation to the equity of state-owned firms.
62. Pratt & Whitney Canada has repaid substantial amounts on the considerable DIPP grants they received.
63. Memoranda of Understanding are a common practice in the industry when different firms have joint development programmes, in order to outline which firms perform what part of an R&D program.
64. See Mowery and Rosenberg, 1982 above.
65. The original framers of the infant industry argument (Hamilton, Ferrier, Chaptal and List) thought such an infant industry policy would take decades and was better enacted through subsidies than through tariff barriers.
66. *Canadian Aviation*, 50th Anniversary Issue, 1978, p.123.
67. This is not to say that in practice the political process does not sometimes corrupt the goals of the policy. Here, we refer to explicit policy goals and guidelines.
68. Sources vary as to the level of government support.
69. This was the case with large turbine technology for the Pratt & Whitney Canada team that went to Hartford to work on the PT6 design.
70. Mowery, D.C. Op cit.
71. Many of these aspects are mentioned in the section 20 of the Investment Canada Act concerning non-Canadian investors.
72. The Pratt & Whitney Canada success story may have been taken by policy makers as a model to reproduce. We suggest that the contingent aspects of technological development, and therefore of public policy, preclude this.

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DISCUSSANT'S COMMENT

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THIS STUDY CONSISTS OF THREE SEPARATE, but closely linked cases: Pratt & Whitney, Canadair, and de Havilland. The most useful aspects of this study are the analysis of the historical development of the firms studied, and the points brought out concerning the importance of the choice of industrial organization made by multinational firms in the development of their subsidiaries. The fact that the parents of foreign-owned R&D firms in Canada often have competing, rather than congruent, interests to their subsidiaries, is one of the important points brought out by the study.

My criticisms of this paper reflect mainly on its lack of linkage to general lessons of industrial organization and policy-relevant issues. To some extent, there are useful generalizations that are relevant to and/or can be advanced from this work. In the former category, it is worth mentioning that the statistics show that, on average, foreign-controlled firms have been much less R&D-intensive than Canadian-controlled firms in the same industry, and that the counter-examples in this group are decidedly exceptional. The extent to which Pratt & Whitney, in particular, is exceptional, is very important for the reader of these studies.

In conclusion, the authors stress that each case is different and that whether or not government attempts to cooperate with individual foreign subsidiaries for industrial development purposes will work depends primarily on the management and strategy of the firm in question. The paper seems to conclude that there is no point in looking for general clues to predict the behaviour of firms:

"Public goals must be clear and persistent, but individual policies must be assessed on the basis of the strategy and performance of the specific subsidiaries, and whether these are likely to help attain these goals."

In this respect the study seems to me to read like a chapter in a "How to" book on industrial policy, while ignoring the more fundamental question of the net effect of economic intervention. This is not, in and of itself, a bad thing. If industrial strategy is to be practised, then it follows that there is a need for manuals as well as polemics and analysis. However, what is bothersome about the study's conclusion is the implication that there is no way to establish guidelines for policy based on empirical rules of firm behaviour. While it is true that any individual case can be a massive exception from whatever general laws are in operation, the study seems to me to beg the important question by giving up on uncovering indicators that can help predict how firms will behave.

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Rapporteur's Comments

THIS CONFERENCE was part of a back-to-basics program in which Investment Canada commissioned studies on the importance of Foreign Direct Investment (FDI) — a subject that is important to the world in general, and to Canada in particular. In these comments, I take up some of the main themes that were of particular interest to the conference organizers:

- the relation of FDI to technological change and economic growth;
- some of the benefits and costs of FDI;
- the scope, if any, for an investment review agency, such as Investment Canada, to influence FDI in welfare-increasing ways and, in particular;
- the arguments for and against some form of intervention.

This agenda gives only scant attention to the papers in this volume that provide important background information, either by way of descriptive material or analyses of the behaviour of transnational corporations (TNCs).[1] For example, Lorraine Eden deals with the reactions of TNCs to the many changes that are currently besetting them. Baldwin and Gorecki present evidence on the differences between low- and high-tech industries, in their turnover rates, and on the consequences of that turnover. Wolf and Taylor tell the important story of technological changes in the North American and Japanese auto industry, while de Bresson, Niosi, Dalpé and Winer (hereafter BND&W) provide a valuable look at the Canadian aircraft industry. Although each of these is mentioned at some point in this commentary, I have not tried to summarize the importance of these contributions to our understanding of the behaviour of TNCs.

In the first three sections, I deal with what the speakers said on these issues. In the later sections, I offer some views of my own.

THE RELATION OF FDI TO TECHNOLOGICAL CHANGE AND ECONOMIC GROWTH

EXTENDED TREATMENTS are needed to give a reasonably comprehensive view of the relation between technology and growth (see Mowrey and Rosenberg, 1989), or even of the more limited issue of the diffusion of technology (see Freeman and Soete, 1990). Thus, we cannot expect to receive an exhaustive treatment of these issues from the participants at this conference. Nonetheless, the contributors made some interesting observations, some of which touch the core of our understanding of the issues. These are summarized below. In the concluding section, I return to these issues to suggest some other approaches to the subject. Insofar as these other approaches deal with policy issues, I would argue that those papers presented at this conference that were neo-classical in their underlying theoretical structures did not — indeed, could not — come to grips with some of the central issues.

TECHNOLOGY AND TRANSNATIONAL CORPORATIONS (TNCS)

CANTWELL POINTED OUT THAT TECHNOLOGY is an incremental, cumulative process that is highly specific to the firm(s), or location, in which it is created. This suggests to me that we are not likely to understand it fully through highly aggregated and/or highly abstracted models of economic growth. Detailed studies, of the sort undertaken by Porter (1990) and others in the U.S.-business-school and the European-technology-analysis traditions, are needed. In short, the events that influence economic growth occur in detailed institutional, motivational and environmental contexts, and these detailed contexts matter enough that full understanding of these events cannot be generated by theories that strip away these contexts. This diversity was supported at the conference by BND&W who found that the effects of foreign ownership are not consistent across 75 industries, but are industry-specific instead. (I return to this issue in a later section.)

The disintegration of production taking place in many industries, as discussed by Lorraine Eden, is of critical importance in evaluating the issues before us. Components are often made by many suppliers located in many countries. Increasingly, however, more and more components requiring the input of unskilled labour are being manufactured in low-wage countries. This development is sufficiently important that some observers now believe that the unskilled labour market will become integrated worldwide, with a resulting equalization of unskilled wages throughout the world.

This is an encouraging development for less developed countries (LDCs), which have a much better chance of developing comparative advantages in less-skilled niches than in the integrated production of whole commodities. Furthermore, the equalization of wages will raise theirs. In contrast, unskilled labour in more advanced countries is likely to suffer. When production is integrated, unskilled labour can command relatively high wages in advanced countries as long as the whole product contains enough high-skilled labour to give the developed country a continued comparative advantage in its production in spite of the higher-than-necessary wages to those unskilled workers who are involved.

Another aspect of this disintegration is that it is no longer certain that R&D will be located within the head office's home country. Also, it is no longer certain that attracting R&D to a country will attract other (related) parts of production to that country.

As Rick Harris observed, large TNCs are becoming truly global in the sense that both their production *and their ownership* are spread over many countries. According to Robert Reich (1989) this leads to some confusion as to "Who Is Us?".[2] The importance of this observation is that it is becoming less and less clear who should be assisted if our aim is to help our economy. For policy purposes, is it reasonable to regard a home-owned TNC, which conducts most of its R&D and production offshore, as one of "us", and a foreign-owned TNC, which does most of its R&D and production in our country, as one of "them"? It is not at all obvious that the answer to this question should be "yes".

FOREIGN DIRECT INVESTMENT (FDI) AND TECHNOLOGY DIFFUSION

On the subject of FDI, all speakers at the conference were generally agreed that the two great benefits of FDI to a recipient country are: the transfer of technology, and the externalities, measured in terms of spillovers generated by the FDI. These are discussed in more detail later.

On the consequences of the transfer of technologies through FDI, there are two competing sets of diffusion models. One set predicts that productivity gaps will narrow as technological know-how becomes more widespread. The other set predicts that technological gaps (and their consequent international wage differentials) will persist as long as technological change continues. Rick Harris endorses the North-South model as an explanation of why the gaps will persist. In it, a constant rate of innovation in the North and a constant rate of diffusion to the South leads to a constant technological gap between the two. I agree with him in accepting the persistence of technology gaps, and note that no one at the conference gave evidence of any narrowing of international differences.

In discussing the transfer of technology through FDI, we must recognize (as Harris points out) two aspects, both of which are important to growth and significant for policy initiatives. From the standpoint of any one country, technology can be *both* imported through inward bound FDI and exported through outward bound FDI. Until recently, importing technology through FDI received most attention in Canada. The case for and against exporting technology was much debated in the United States in the 1960s, however, when American TNCs were accused of exporting jobs to foreign countries. (In a literal sense, they did, of course, export jobs, since TNCs do create jobs abroad, but this does not necessarily imply that their actions resulted in a net loss of domestic jobs.)

Although outward bound FDI was not much discussed at the conference, it is almost as important to Canada as inward bound FDI. Harris observes that existing literature shows that technologically advanced countries can and sometimes do lose important economic benefits and advantages by speeding up foreign transfers of their knowledge. (This result follows from a long-run model in which existing rents are dissipated. Using a dynamic model in which the rate of home innovation in a specific industry depends on the volume of its exports and its foreign investment,[3] that result does not necessarily follow.)

THE BENEFITS AND COSTS OF FDI

NO ONE AT THE CONFERENCE doubted that large flows of inward and outward bound FDI are both necessary and (usually) beneficial. Two basic reasons not mentioned during the proceedings are worth noting at the outset.

The Supply of Locally Owned Wealth Canada is typical of many resource rich countries in that its relatively small population does not have a large enough stock of wealth to own all the equity and debt needed to operate its economy at a high level of activity, *plus* all the capital that must be held abroad, which is needed by Canadian-owned TNCs and investors seeking portfolio diversification. In other words, given the needs for international diversification on the part of Canadian TNCs and investors, the stipulation that virtually all gross wealth located in Canada be voluntarily owned in Canada would require a stock of Canadian-owned wealth that is substantially greater than the present stocks that are Canadian-located or Canadian-owned.

Globalization Requires Substantial Foreign Ownership Much of the world's total production as well as the majority of its international trade and international investment flows are in the hands of large TNCs. Because of globalization through TNCs, no small country can expect to own more than a small part of the TNC capital operating within its borders. To insist on home ownership of the home-located TNC capital would be to require that Canada own much of the world's TNC capital, which is wildly beyond the means of any small nation. The alternative would be for local production to be owned by local firms rather than TNCs. This, in turn, would require massive levels of protection of inefficient local industries — levels of protection which would be inconsistent with our international commitments, including our membership in the GATT.[4]

I now come to the many benefits and costs of inward bound FDI that were covered at the conference.

Technology Transfer Both Harris and Blomström make the point that there is no real substitute for FDI as far as most technology transfer is concerned.

Within any TNC, there is a continual flow of technology transfers through the five mechanisms listed by Blomström: documentation, education and training, exchanges of technical personnel, development and transfer of specialized equipment, and trouble shooting. Harris observes that, because TNCs provide the main channel of international technology transfer, portfolio investment and other arm's-length relations (such as licensing) are not good substitutes for FDI. According to Blomström, the more modern and complex the technology, the less likely it is for TNCs to accept any arrangements other than wholly owned subsidiaries.

Blomström also observes that, since many leading-edge technologies are prohibitively expensive for small countries to develop on their own, they gain from technology transfers through TNCs. Small countries might therefore be well advised to put less emphasis on developing leading-edge technologies and more on promoting the widespread dissemination of technological capabilities. For them, it may be more important to have the capability to use the best technologies imported from abroad than to develop the best technologies at home.

In their study of the aircraft industry, BND&W evaluate the contribution to innovation of Canadian-owned and foreign-owned companies. They focus on external innovation linkages: the use made by the innovating firm of key components supplied by local firms, and the early use of the innovation by other firms which are often locally owned.

According to Cantwell's theory of technological competence, TNCs will locate research in countries with similar fields of technological competence thereby internalizing spillover effects. Host countries with high degrees of technical competence derive benefit, as do countries with low levels of technical competence, but in other ways — mainly increased employment and upgrading by domestic firms. However, according to this theory, there is an intermediate degree of competence where expansion of foreign firms reliant on research carried out abroad may hurt the host country — because they will successfully take market share away from local firms which will then decline in terms of profits and research capability. Ed Safarian disputes Cantwell's intermediate case. I, too, am not inclined to accept it as a general phenomenon in the absence of, first, further systematic evidence of its existence in "middle-range countries" other than the United Kingdom and, second, a serious consideration of other explanations of failures in the U.K., such as union and management attitudes.

Spillovers These externalities include everything that derives from FDI other than technology transfers. Examples include increased competition, efficient behaviour forced on domestic firms, and the training of local suppliers of intermediate products to meet high international standards.

BND&W argue that technological externalities include the public goods aspects of processes used by other firms; the imposition of product standards; induced product innovations to pursue new developments; the training of R&D

staff, product designers and marketing personnel, and the incubation of technologically based spin-off firms.

Blomström suggests the following spillover process. First, FDI often increases competition and forces domestic firms to become more competitive because foreign firms often have competitive advantages that allow them to enter domestic markets that have sufficiently strong entry barriers to deter potential new domestic entrants. Second, the competition from TNCs in turn forces domestic firms to adopt more efficient management and labour practices. Third, imported TNC technology acts as a catalyst, increasing the pace at which competing products and processes of domestic origin appear in the markets.

To Compensate for a Competitive Failure Firms may fall behind in the technological race either because they do not sustain their effort or they make wrong strategic decisions, as did the North American auto manufacturers as documented by Wolf and Taylor. In such circumstances, restrictions on trade and foreign investment will only make matters worse. FDI, however, provides an opportunity to catch up by importing foreign "best practices". This may require building new best-practice plants (such as auto assembly plants) or simply importing foreign management expertise (as in the aerospace industry).[5]

Bernstein supports this point when he shows that (except in the food and beverage industry)[6] foreign affiliates seem to get more cost reduction out of R&D spillovers than do Canadian-owned firms. BND&W also illustrate the point when they observe that foreign-owned firms tend to perform better than Canadian-owned firms in extractive industries; foreign firms have been willing to develop new best practices whereas Canadian firms have been content merely to copy what has been developed elsewhere.

To Provide Financing That is Lacking at Home At the conference, this point was mainly made by Teece. Although his arguments and policy recommendations would have carried more weight in the light of his long-term study, which is still to be completed, his point is supported by the work of other researchers, especially Porter.

The analysis runs as follows. The United States (and Canada) seem to have an ample supply of risk takers who are willing to become involved in start-up firms, both as innovators and financiers (who are mainly "Angels"). This is consistent with Patel and Pavitt's observation that Canada has a disproportionate number of patents filed by individuals and small firms. Once these firms get past the first stages of expansion, the best route to world-wide marketing is often to sell out to another (larger) firm with three key characteristics: existing world-market access, large-scale, "patient" capital, and manufacturing expertise for large-scale production. Increasingly, these criteria can be met mainly by TNCs. Hence, foreign capital is providing much of what is lacking at home.

The differences between potential domestic and foreign buyers constitute more than just the cost of capital, although that consideration is important.[7]

They also relate, as Porter has extensively documented, to management practices and remuneration, as well as firm organization.[8] This is not a reason to restrict foreign investment, without which innovation will be hampered; it may, however, be reason enough to try to alter the infrastructure in the United States and Canada, so as to improve education and working skills, increase savings and employee commitment, and extend time horizons for planning.

In contrast, Globerman argues against the existence of significant capital market imperfections. To my mind, however, the international behavioral differences documented by such writes as Porter, Mowrey and Rosenberg, and Teece, and the differences in measured cost of equity established by other investigators (and discussed in more detail later), do not suggest a perfectly functioning, single, world capital market such as is described in neoclassical theory.

THE SCOPE FOR INTERVENTION

SOME CONTRIBUTORS CONSIDER the question of the scope for an investment review body such as Investment Canada to intervene or to influence FDI in welfare-increasing ways. Three views on intervention were expressed at the conference. First, there were reasons for intervention in order to restrict the volume, or the terms, of the flow of FDI. Second, there were reasons for intervention in order to encourage the flow of FDI. Third, there were reasons for operating a policy of *laissez faire* with respect to FDI.

REASONS TO RESTRICT FDI

To Capture Oligopoly Rents Compared with industrial-organization economists, international-trade economists were late in understanding the importance of the fact that most manufactured goods are produced under conditions of oligopoly. According to Rick Harris, the main policy message of the new strategic trade theory is that oligopoly rents exist, and can be captured by government action designed to establish domestic firms in oligopolistic markets. These rents arise from the market power in goods markets, and appropriating them requires political power sufficient to affect market outcomes. Harris points out that the case for strategic trade policy is not as strong as it was first thought to be since it depends on a number of stringent conditions that are unlikely to be met in practice.[9]

The strategic case also depends on a model based entirely on long-run conditions, where very-long-run behaviour with respect to product and process innovation is independent of the government's attempts to capture oligopoly rents for domestic firms.[10] Since, as I argue in the next section, oligopolistic competition always involves such very-long-run strategic variables as product and process innovation, it is risky to assume that oligopolists will continue to generate rents irrespective of the government's behaviour. If the government's strategic trade policy influences the very-long-run behaviour of oligopolistic firms, this should be factored into the analysis.

To Encourage Effective Retaliation The retaliation game may not be prisoner's dilemma. Harris argues that, given even slight asymmetries between two countries, the unilateral strategic policy may be superior even in the event of retaliation. This may not justify intervention in itself, but it removes a potent argument against it by showing that a round of retaliations may not leave the original mover worse off than it was before the game began.

To Raise the Selling Price to the Reservation Price of the Foreign Buyer If rents are being earned by a local firm, these will be split between the foreign buyer and the local seller. Intervention may be justified if the local seller is unable to gain the majority of the rents by means of its own bargaining efforts.

Globerman points out that the empirical literature suggests that sellers get most of the rents from domestic takeovers. This is an important observation, and further work should be done to see if the characteristics of foreign takeovers are significantly different from those of the domestic takeovers that generated this evidence. Globerman also surveys a number of foreign takeovers of high-tech firms and concludes that an amount close to the reservation price is usually paid. In support of this view, Globerman asks: "Why should a foreign firm be able to outbid potential domestic buyers and still obtain significant rents?" My answer to his question is that, if the purpose of the sale is to integrate the domestic firm into a TNC network, as was the case with Connaught and de Havilland, the firm would be of much less value to a domestic buyer, which would have to operate it on a stand-alone basis, than to a TNC.

To Encourage Local R&D One policy tool to achieve this effect is performance requirements that call for local R&D when a takeover occurs. The argument is that R&D may be relatively footloose and can remain domestically, or be transferred abroad. Holding R&D locally may encourage the subsequent development of a world product mandate for the domestically located branch of the TNC.

Globerman suggests that these, and most other performance requirements, reduce the value of a purchase to a buyer and so reduces what the buyer is willing to pay for other aspects of the deal. In this case, the value of the trade-off between encouraging R&D and the reduced value of the sale in other dimensions must be assessed.

Against his arguments I place two considerations. First, the R&D performance requirements may be one way to get closer to the buyer's reservation price. Second, the cost to the buyer of a local R&D commitment is the net difference between the value of the R&D when done locally and its value when done in the best location; the benefit to the local country is related to the *gross value* of the R&D. Frequently, the R&D is almost as valuable to the TNC when it is carried on in different countries. In such cases, the local country gains by imposing R&D performance requirements, even if their full net cost to the purchaser is deducted from other aspects of the sale.

Blomström gives an important warning when he points out that increased R&D effort may not result in gains to the country in which it occurs. This is because, as part of the general disintegration of industrial activities, R&D can be decoupled from all other activities. Blomström also points out that in Sweden, R&D subsidies have attracted R&D to develop processes and products that are then produced elsewhere.

Once again, this raises the issue of the headquarters effect. It the past, it was assumed, following the practices of American TNCs in the 1960s, that R&D would go almost automatically to the TNC's home country. Today, this is no longer certain. Contrary cases were cited at the conference, and the press has recently reported that the Japanese are beginning to shift some aspects of their R&D to the United States.[11] These reports have given rise to a new worry that the Japanese will capture all the best American R&D talent, thus illustrating the dictum that all change is bad to the critics. (According to the critics, it is bad when foreign firms transfer R&D abroad because it creates a "hollow corporation" at home; it is also bad when they move R&D to the United States because it attracts researchers away from American firms!)

To Avoid a Serious Reduction of Competition BND&W point out that there are grounds for intervention into takeovers when they create market power and when the innovation activities of the firm doing the buying, and the firm being bought, are substitutes. (If the firm being bought out and the foreign acquirer are complementary in their activities, there is less reason for intervention because competition is less likely to be reduced by such a transaction.)

It seems to me that, if domestic competition laws are adequate, they should be able to take care of increases in market power, whether generated by a foreign or a domestic buyout. If the competition policies are not adequate, however, the foreign investment review body might provide a second line of defense in the case of foreign takeovers.

To Protect Firms in the Technological Middle Range I have already noted Cantwell's theory that industries somewhere in the middle range between technological sophistication and technological backwardness may lose out from foreign FDI. If they lose enough, the entire economy may suffer. This argument goes a long way toward making a case, not just for performance requirements, but for restricting some types of FDI to protect the domestic industry. The case, however, is not proven, and must therefore be taken as highly conjectural until the concerns about the adequacy of Cantwell's argument are seriously addressed. Moreover, it must be shown that domestic protection will contribute to a more rapid rate of technological advance on the part of the domestic countries than would otherwise occur if foreign firms displace domestic firms. Porter provides an enormous body of contrary evidence showing that a high degree of competition in the domestic market is almost a *sine qua non* of a dynamic, technologically progressive industrial base.

Japan Did It According to Cantwell's theory, a carefully managed process of intervention (as outlined by Saffarian) can be beneficial to a country. This is essentially the Japanese model of the decades up to the 1980s. (Current Japanese policy is much less interventionist.) As Saffarian observed, however, this proposition would be more convincing if it could be shown that another country had successfully applied the same policy. In the circumstances, we must wonder if what we really learn from this discussion is that Japan is, again, a special case in yet another aspect of its behaviour.

REASONS TO ENCOURAGE FDI

TWO CLASSES OF REASONS were advanced at the conference in support of intervention to encourage foreign direct investment.

To Maximize Technological Transfer Blomström suggests that a small country should concern itself with encouraging the transfer of best practices from abroad rather than inventing them itself. This suggests that small countries should (therefore) seek to maximize the rate of technology imports *that will maximize spillovers*, and that they should eschew domestic performance requirements on the grounds that these will discourage technology imports. This policy advice is based on the evidence that technology transfer to the host country is *an increasing function of* the level of income of the host country and *a decreasing function of* the level of domestic distortions and imposed performance requirements.

It is reasonable to ask at this point: What can an organization such as Investment Canada do to encourage maximum technological transfer? It seems to me that when considering this question, we need to know more than we do at present about the linkages between basic R&D and production based on R&D, in order to understand the implications of focussing policy on one or the other.

To Obtain a Critical Injection of FDI at an Early Stage in the Product Cycle BND&W point out that the stage in the product cycle at which FDI occurs is important. The earlier it happens, the more likely it is that the domestically located facilities will thrive. This suggests a role for an agency such as Investment Canada to help attract foreign subsidiaries *at the early stages in the technology cycle*.

IN SUPPORT OF A *LAISSEZ FAIRE* POLICY WITH RESPECT TO FDI

FOLLOWING, ARE ALL THE REASONS offered at the conference under this heading in what seems to me to be an ascending order of importance.

Intervention May Lose the Deal Globerman argues that attempts to extract concessions from a potential purchaser may contribute to the collapse of the deal. Such negotiations take time and involve high stakes. This means that negative signals (such as asking for too much) will be transmitted long before a deal finally falls through. It seems unlikely, however, that a foreign investment review agency whose motivation is to encourage FDI, but on the best terms possible for the country, would often make such mistakes.

Arbitrage of Interventionist Economic Policies TNCs, by virtue of operating in many countries, have enormous ability to arbitrage national economic policies. They can locate production in areas where cost subsidies are greatest, and profits in areas where taxes are lowest. This power has been greatly strengthened by transportation and communications revolutions which have allowed a firm's activities to be divided into many segments with each segment being carried on in a different location.

These difficulties do not justify giving up on policy intervention, but they do provide reasons for exercising extreme caution in designing policies and following up on their consequences. Once a policy is in place, many policy makers are reluctant to follow up on it lest they, and their critics, discover that the policy is flawed. Interventionist policies conducted in such an uncritical atmosphere are much more likely to be counterproductive than those conducted by agents genuinely willing to alter their policies until desired results are obtained. In the world in which we live, this is a pretty stringent requirement.

Ownership is Irrelevant The argument here is that the nationality of owners is irrelevant. Policies based on influencing ownership are therefore useless at best and harmful at worst. To paraphrase Rick Harris: In a world of mobile capital among developed countries, and assuming the *ex ante* R&D market to be competitive, it would be likely that differential incomes across countries would accrue in the form of returns to the specific factors. The ownership identity of firms would be of no particular national concern. What would be of concern would be that the country as a whole have a reasonable share of innovating industries — that it be in the innovating North and not the imitating South. There are a host of other policies which might affect where a nation would sit on this spectrum but policies directed at ownership *per se* would need to have little to do with it.

Limited Scope Unless Favourable Conditions are Already There Cantwell's theory of technological competence suggests that there is only limited scope for inducements to foreign firms to spur local technological development. According to his theory, not much will be accomplished by TNCs unless the conditions are already there.

This may be so, but it raises the question of how the conditions came to be there in the first place, particularly in countries that have not always been technologically advanced. It suggests that local indigenous activity is always the cause. Since this seems unlikely to me, it also seems likely that there are conditions under which foreign firms help to create technological sophistication where it does not originally exist.

Loss of Value for Canadian Innovators Several authors argued that restricting the conditions on which a local innovator can sell out reduces the return to the innovator and hence reduces future local innovating activity. This is a potentially serious issue, whenever governments intervene in the sales of the small firms that innovators typically sell to larger firms. Against this must be set two considerations. First, most interventions into foreign takeovers involve large firms and so, whatever disincentive the anti-takeover activity exerts, it is not likely to be on individual innovators. Second, most innovators are "maniacs with a vision" (venture capitalist Gordon Sharwood's term) and hence their behaviour is unlikely to be influenced by small changes in the expected returns to innovation brought about by government policy.

May Slow the Rate of Technology Transfer Blomström made the point that restricting the conditions on which a foreign takeover can proceed reduces the benefits to the buying company. This, he argued, may slow the rate of takeover and, hence, slow the rate of technology transfer.

May Inhibit Effective Competition Baldwin and Gorecki begin their consideration of this point by observing that the screening of inward foreign direct investment in high-technology industries would deserve serious consideration as an instrument to promote such industries in Canada if high-technology industries are distinct, foreign firms important, the number of mergers quite small — thus making screeening easy — and the impact of foreign acquisitions neutral, at best, and adverse at worst. They go on to argue that these conditions are not fulfilled. First, high-tech industries are different from many other industries in that they have high growth rates, and high export and import propensities; second, foreign firms are important in the high-tech sector but, surprisingly, their importance has been decreasing over time; third, turnover of firms is important because this is the point at which ownership changes and the policy intervention occurs. This turnover activity is large and important. It is as large as elsewhere in the economy but, unlike some other sectors, the turnover is associated with large productivity gains and improvement in most other performance criteria.

The importance of the turnover process operating through the opening and closing of plants and the merger of firms, makes this sector particularly dependent upon the dynamics of the competitive process. Interruptions of that process by a government screening agency could, therefore, be particularly harmful.

Globerman challenges the claim that foreign acquisitions are associated with significant efficiency gains. According to Globerman, the evidence surrounding the existence of efficiency gains to mergers and acquisitions is itself less than persuasive. The studies done for the Royal Commission on Corporate Concentration did not find evidence that efficiency gains were a ubiquitous feature of the acquisition process. Indeed the available evidence suggested that such gains were difficult to identify in a large number of cases covering different industries. Nor does the evidence for Canada seem much different from that for other countries.

THE PROBLEM FACING INVESTMENT CANADA

ALL THE ECONOMISTS AT THIS CONFERENCE, and the great majority at large (myself included), agree with *Investment Canada's main philosophy* that foreign investment is good for the country. Most would agree, therefore, that, faced with a simple yes/no choice on FDI, the choice would be yes (almost) every time.

I suspect, although I stress that I am speaking as an outsider, that the choices open to Investment Canada when it reviews a proposed foreign takeover are not so simple. Often, the agency may have little choice but to press for relatively marginal changes in a deal that has already been agreed to in principle by the parties. At other times circumstances may limit Investment Canada's influence to pressing for alterations in the form of performance requirements. Sometimes, it might be required to recommend a choice between two more-or-less similar deals. At other times, it might conceivably work behind the scenes to encourage a new deal were it is dissatisfied with existing offers. There is little in this volume to help Investment Canada make decisions on issues such as these when they do arise.

To work out relevant theory, economists need much more fully specified cases than we find in the (useful but limited) first-pass theories contained in this volume. It seems to me that the theories would benefit from the following more detailed specifications.

POLICIES IN CONTEXT

GOVERNMENTS HAVE MANY POLICIES: competition policy, trade policy, monetary and fiscal policy, and policies with respect to what data to collect and what to leave uncollected. All too often, these policies are adopted on a piecemeal basis and with little coordination. When asked to consider a specific topic, such as FDI policies, however, economists who hope to develop more rational models of behaviour must take these other policies into account. For example, how can policies with respect to FDI be made to reinforce, rather than offset, the effects of competition policy?

CAPITAL MARKET CONDITIONS

I HAVE ALREADY ALLUDED to the strong evidence that the cost of equity capital is lower in Japan and Germany than in all other industrialized countries. Perhaps it comes as a surprise to Canadians, used to complaining about the wide spread between American and Canadian interest rates, that such discrepancies do not apparently exist on debt capital. After allowing for inflation and exchange-rate risk, debt capital seems to be about the same price throughout the world. The differences lie in the cost of equity capital.[12]

The reason for this is that the market for debt is global. Investors throughout the world can assess the risks associated with a treasury bill issued by any government and denominated in any major currency. This is not, however, the case with equities. Here, investors in one county have difficulty assessing risks and probable returns on the many equities listed on many foreign stock exchanges. As a result, equity prices are strongly influenced by such local conditions as national savings rates and local demands for equity financing.

Economists must do some careful thinking about the social returns to foreign takeovers under these conditions. Perhaps it does not matter, but the frequency with which one encounters the assumption of perfect world capital markets makes me want to see the theories reworked based on the empirically relevant assumptions of (i) a perfect debt market and (ii) partially segmented equity markets.

THE BEHAVIOUR OF OTHER ACTORS

MOST OF THE THEORIES discussed during this conference did not consider the behaviour of "foreign" governments. Is it really true that the optional behaviour of the Canadian government with respect to FDI is independent of the behaviour of other governments? If so, surely this is something that should be established, rather than assumed.

There are two key ways in which other governments can affect the domestic situation. First, they may control *our* ability to take over *their* firms and hence to establish *our* TNCs in *their* countries. Second, they may assist their firms, which may be state-owned or just state-aided, to buy up our firms.

At a time when many foreign governments are following one or both of these strategies, is our best strategy to continue with a *laissez faire* approach? To take an extreme case, what if the nationalized industry in country X offers to buy our firm Y, which is its only serious competitor world wide. In concrete terms, should the United States allow the *Airbus Internationale* to buy Boeing?

In more general terms, what is the best strategy for the domestic government to adopt when other governments are playing a strategic game? Is "tit for tat" a good policy choice? Does it matter if the foreign governments consistently follow some clear strategy or if, as so often happens in democracies, they follow varying, and sometimes inconsistent, strategies?

Surely, there is room for some important, policy-relevant research and theorizing on such issues.

WHO GETS THE RENTS?

IN HIS ANALYSIS, Rick Harris followed the standard practice of assuming that all rents accrue to the owners of capital. This is crucial to some of his policy conclusions.

Voluminous empirical evidence shows that a large portion of the rents obtained from natural, or state-created, oligopolies accrue to labour rather than to capital. For example, deregulation of airlines in the United States showed that flight crews earn wages well above their opportunity costs. Also, workers in the North American automobile industry earn well above their market-clearing wages. (Long queues appear whenever any of the big companies announce their intention to take on new workers.) Finally, workers at Canadian beer plants (closed recently by the rationalization following the merger of Carling O'Keefe and Labatt's) were earning substantially more than they could elsewhere even though they were doing relatively unskilled jobs.

This helps to explain why the Canadian provincial governments and American state governments scramble to have foreign firms, such as auto assemblers, locate within their jurisdictions. One reason is that these industries pay very high wages and hence bring prosperity to a locality far in excess of what would be provided by firms earning, and hence paying, only competitive returns. In contrast, Rick Harris' model would predict that such governments would not care much since this surplus would all go to foreign owners.

VERY-LONG-RUN COMPETITION

THE MESSAGE FROM THE EMPIRICAL LITERATURE is that on-going competition in the markets for manufactured goods (and many services as well) *always involves very-long-run variables*. At any point in time, oligopolists are making three types of decisions: short-run decisions to set prices and/or outputs, long-run decisions to establish the amounts and types of capital manufactured from existing blue prints, and very-long-run decisions on such things as how much to spend on R&D, and what types of new processes and new products to try to develop, or to adapt from the work of others. Oligopolists in today's knowledge-intensive world are in constant competition with respect to new products and production processes. Indeed, these issues play at least as important a part in strategic decision-making as those relating to existing technology and decisions made with respect to capacity and output.

There is some excellent empirical research and theorizing, particularly from European scholars, on the conditions conducive to technological change and the diffusion of technology. Most purely theoretical models, however, are rooted in the long-run — although highly aggregated models, with endogenous technological progress and increasing returns to investment in innovation, are now being developed. At the microeconomic level, a few theorists, such as Nelson and Winter, have been working on evolutionary models of the firm for more than a decade. The models normally used by North American economists (when they are asked for policy advice) are, however, still predominantly neoclassical. For example, the new theory of strategic trade policy surveyed by Rick Harris says nothing about very-long-run decisions. It therefore has dubious applicability to the oligopolistic competition that actually occurs.

What is needed is a new theory that encompasses oligopolistic competition in the very-long-run. The firm's decision variables for such a theory are:

(i) R&D for its own process and product invention and innovation,
(ii) R&D to adapt inventions and innovations made elsewhere,
(iii) investment in capital to embody new processes and to produce new products,
(iv) investment in capital to produce existing products with existing technology, and
(v) volumes of production and selling prices.

Developing such a theory is a formidable task, but it is important because the evidence is clear that firms in oligopolistic situations rarely ignore very-long-run considerations, and those that do will not survive long in today's world of fierce global competition. Until this is done, we must register a strong note of caution. Almost all theories, including Rick Harris' contribution to the present volume, go no further than the long-run. The main issues concerning Investment Canada, and what we care about in our country — the preservation of competitiveness and high-value-added jobs — all turn on very-long-run considerations. It will probably be many years before we have acceptable theories relevant to these key considerations. In the meantime, we must be wary of using existing Industrial Organization and International Trade theories to predict behaviour in oligopolistic markets.

THE UNDERLYING STRUCTURE FOR THE ANALYSIS

THE PAPERS GIVEN AT THE CONFERENCE included many approaches to understanding and interpreting the significance of FDI. On the subject of controlling FDI, however, the neoclassical approach underlies most of what was said. Much of the theoretical underpinning for the case in support of positive intervention to affect the terms of foreign takeovers is found in the modern theory of positive-feedbacks in increasing-returns systems associated with such names as Brian Arthur, Paul Romer, Gene Grossman and Eliah Helpman. Because this stream of theory was under-represented at the conference, the theoretical case in support of Investment Canada in exerting selective influence on FDI did not receive full consideration.

In what follows, I outline some relevant parts of non-neoclassical theories. Space does not permit me to do more than scratch the surface, but my purpose is to say only enough to suggest to readers that the cases that follow from neoclassical models do not necessarily exhaust the class of cases that are potentially relevant to policy. Indeed, the research that I describe below will be quickly recognized as being non-neoclassical.

THREE THEORETICAL PARADIGMS

THREE RATHER DIFFERENT VIEWS of the world compete to provide theoretical explanations of the issues addressed at this conference. Although I see no reason to encourage "a clash of methodologies" and feel that economists should use whichever tools seem appropriate for the job at hand, it is important to realize that the points of view presented by these paradigms are profoundly different.

The Neoclassical View

As is well known, the neoclassical view is non-historical; it leaves little place for institutions, it treats the firm as a black box, and is based on maximizing models. These models often have unique, stable equilibria so that the effects of small perturbations quickly die out. In the neoclassical world, a given shock, such as a rise in the price of oil or of labour, will have a unique effect in all market economies.

The Historical-Business School View

Economic historians, such as Nate Rosenberg and Paul David, and business school economists, such as Michael Porter and David Teece, tend to see processes as being irreversible in time. In this context, history matters, institutions and the internal structure of the firm are important, and non-maximizing behaviour may serve to explain some events. According to this view, a given shock can have radically different effects in different economies, depending on the detailed environment of these economies. The motto of this view could be: "Things happen in contexts, and the details of the contexts matter.". This is a much richer view than the neoclassical one, in the sense that many more detailed factors influence economic events. The danger is that studies in this spirit may loose the guidance of a theoretical structure and degenerate into mere story telling.

For decades, European economists have also been careful students of science, innovation and diffusion. This has enabled some of them to develop theories set in detailed contexts, such as Cantwell's theory presented at this conference. I may insult these economists by suggesting that their theories conform to the business-school tradition. Whatever the name used, however, they do represent the tradition discussed in the previous paragraph.

New Theoretical Views

Many non-neoclassical views are apparent among today's theorists. More recent views stress such things as positive feedbacks, path-dependent and multiple equilibria, increasing returns, irreversibilities, and evolutionary processes in the absence of any equilibria. Long-term social processes, clearly, have no equilibrium.

The social and psychological attitudes of each generation evolve out of those of the previous generation and so are amenable to rational explanation. But readers of any multi-generational chronicle, such as the *Forsyte Saga*, cannot doubt that what they are reading about is not a stable social system where small disturbances are quickly damped and the original equilibrium is restored. Similarly, when the technology of goods and production processes is changing, the entire system cannot be analyzed as an equilibrium system. Because the technological system of each decade evolves out of the system of the previous decade, we can try to understand the forces of history. We cannot, however, analyze the whole process as an equilibrium system. (Of course bits of the whole, such as single markets, may react like the strange attractors of chaos theory, and be amenable to understanding as equilibrium sub-systems.)

Which View? The neoclassical and the newer views are not mutually exclusive. For example, the new theoretical models are sometimes based on high levels of abstraction and aggregation, similar to those that underly neoclassical models. On the other hand, the business school-historical approach overlaps more with new theoretical views than with neoclassical models.[13]

SCIENCE AND TECHNOLOGICAL CHANGE

WHAT FOLLOWS IS A BRIEF DISCUSSION of just a few of the ideas found in the non-neoclassical literature[14] concerning the relationship between science and technological change.

The Nature of Technological Change As Dosi and Orsenigo see it, the behaviour of the firm and the industry (and by aggregation the economy) is influenced by the nature of the technological change which surrounds them. Some key characteristics are:

- sector-specific opportunities and degrees of appropriability,
- variety in the knowledge base of firms and in their search procedures for innovation,
- a high degree of uncertainty,
- irreversibility caused by the typical dominance of new over old techniques irrespective of relative prices,
- the endogeneity of market structures.[15]

The *cumulative*, *localized* and *irreversible* forms of technical progress yield:

(i) non-predictability of equilibria,
(ii) inflexibility (random walks with absorbing barriers),
(iii) non-ergodicity (hysteresis effects), and
(iv) potential inefficiency from some static welfare points of view.[16]

Maximization and Non-maximization Markets may work efficiently when decisions are being made about what is known and about future states of the world to which probability numbers can be ascribed. Markets cannot deliver knowledge about, or discount the possibility of, future states of the world which arise as the unintentional result of present decisions taken by heterogeneous agents characterised by different competencies, beliefs, and expectations. Under these conditions, maximization is impossible, but forward-looking, purposeful behaviour can occur. The outcome of such behaviour will depend on agents' expectations, their problem-solving rules, their specific knowledge, and how all of these things evolve over time. Thus, decision rules used by agents, and the institutions in which they operate, significantly affect market behaviour.

The technological path followed by firms and industries is evolutionary — that is, it occurs as a result of experimentation and trial and error. It is also irreversible and cumulative. Thus, history conditions the present so that even if a firm wanted to go back to "square one", it cannot do so because it cannot escape the experience of having been in "square two". The technological path of firms and industries is also self-organizing in that it is largely the unintentional outcome of innovating decisions.

Equilibrium Since technological evolution is continuous, static long-run equilibrium does not occur in practice. Predictions derived from theories of static long-run equilibrium can therefore be profoundly misleading. In the growth process, however, equilibrium can take the form of a set of structurally stable strategies that agents continue to use as long as the strategies achieve satisfactory results.

The evolutionary environment, and the selection process, are not independent. Everyone's rules of behaviour do influence the criteria of selection, which is why the overall process cannot be captured in games theory.[17]

From Scientific Discovery to Innovation Economists tackling this difficult problem are seeking to understand the link between science and technology. To do so, requires an understanding of the overall process within which a scientific discovery is: first made outside the firm; goes through the precompetitive stages of development; finds its way into the firms' research agenda; and then into process and product innovations. This requires, among other things, going "inside the black box" to understand the process of the formation of new products and new processes.[18]

A well-known European policy advisor and theorist of Industrial Organization recently told me that, in his view, policy advisors and policy makers do not adequately understand the linkages of science-driven technological change from the lab to the shop floor *and the feedback effects of such changes in the other direction*. He believes that attempts to manage particular stages of this process will not work unless the entire process is understood and, if necessary, managed. Although the older school of economists do not understand this process either, he feels that the newer breed of economists is doing important work to advance our understanding of the subject.

Diffusion of Technological Knowledge Mowrey and Rosenberg, in their recent book on technology and economic growth, deal with the topic of diffusion in some detail. They argue that neoclassical theory devotes too little attention to the process by which research is converted into commercial innovation. R&D is not identical with innovation. Innovation couples technical aspects (R&D) with economic aspects (to produce and market commodities, etc.). In this connection, they note that firms do not live in a neat orderly world where causation is unidirectional and clear. Instead, surprising things happen all the time and causation is in all directions. Furthermore, the output of basic research is rarely a simple quantifiable, and marketable, product or process.

It follows, according to Mowrey and Rosenberg, that there is no real line between basic and applied research. On the one hand, many basic discoveries emerge from studies that originally had applied objectives. On the other hand, managers who finance basic research know that a successful outcome may well include practical applications.

> "Expansion and enrichment of this framework (for analyzing R&D) are needed because of the weak guidance provided by the appropriability analysis for public policy makers and managers alike. This framework's lack of attention to the utilization of the results of research and to the ways in which the organization of research affects utilization means that it can contribute little to such debates as the effects on the performance of Bell Telephone Laboratories of the divestiture by AT&T in 1984 of its regional operation companies..."
>
> (Mowrey and Rosenberg, 1989, p. 16)

Theories of the Internal Structure of the Firm The authors mentioned above are calling for theories of the internal structure of the firm. One reason for concern about this issue is described by Mowery and Rosenberg as follows: "Changes in the economic and technological environment are eroding the historical dominance of the intra-firm governance of technological innovation within the U.S. economy." (p. 236). Theories of the internal behaviour of the firm are now beginning to be directed at the firm's ability to govern technological innovations.

Metcalf (1989) makes the point that "... it appears to be impossible to treat the technology of a firm independently from its organizational structure". In his view, this is a major reason why technologies contain such substantial elements of tacit knowledge that are difficult to transfer to other firms. From that point, he concludes, in agreement with the already-mentioned views of Dosi and Orsenigo, that it is dangerous to use the long-run as a tool of analysis. In the long-run, all knowledge is freely available to everyone, and firms eventually achieve equilibrium with respect to the existing technology of products and processes. In reality, however, the world is really a succession of changing short-runs. Not only can the long-run never be achieved, attempts to apply the results of long-run studies will be misleading.

AN APPROPRIATE TRADE MODEL

STANDARD (non-growth) trade models assume fixed supplies of internationally immobile factors: land, labour and capital. They assume that production functions are known, unchanging, and the same in all nations. Markets, including the one for foreign exchange, are assumed to reach equilibrium. As a result, all factors are fully employed, all production is sold, and, in the absence of foreign capital movements, trade is always in balance. These characteristics are useful in showing the market forces that tend to produce them. For purposes of understanding growth and technology in an international setting, however, they are far removed from the characteristics that the earlier discussion suggests are important.

The newer growth models in an international setting incorporate endogenous technological change and sometimes exogenous supplies of some types of capital. This is a great step forward. However, several more steps are needed if models are to be capable of addressing the issues identified as important in the applied literature. Here are six that seem important to me.

1. The labour supply should not be exogenously determined. The volume of immigration and emigration depends on local economic factors. Also, with elaborate welfare safety nets, the labour force may shrink, rather than the wage rate falling, when demand falls. Per capita living standards then fall because there are fewer workers supporting the same total population. Models of full employment normally assume that the employed population is also the consuming population (or a constant fraction of it).

Treating the labour supply as endogenous makes meaningful the discussion about the "quantity" of jobs, which economists find so perplexing when they enter debates about altering trade and investment restrictions. They argue continually, but ineffectually, that the discussion should be about the "quality" of jobs not their "quantity".

2. The quantity of human capital should be an endogenous variable.

3. Production functions in the same industry should vary from country to country (in more detailed models, from firm to firm).

4. Diffusion of technological knowledge should be a costly and time-consuming activity.

5. Local capital formation, and the emigration and immigration of capital, should also be endogenous.

6. A finer division of factors than just land, labour and capital is required. Something more detailed than the traditional division seems to be called for to capture the reality of international comparative advantage as described in the applied literature.

It is easy to order from this menu, but difficult to deliver. Without these features, however, we do not have the framework for a fully adequate model. It may therefore be impossible to make contact with some of the circumstances the empirical literature suggests are important.

CONCLUSION

ECONOMISTS, FOR QUITE UNDERSTANDABLE REASONS, tend to rely on general rules of behaviour such as "make the system more competitive". Unfortunately, the nature of the cases in which Investment Canada becomes involved makes each special. Investment Canada inhabits the world discussed in the previous section. That world is non-ergotic; in it equilibrium, if it exists at all, is often path-dependent, and single decisions taken by isolated individuals can have enormous long-term consequences.

For example, if de Havilland had agreed when Hawker Siddeley told it to stop work on its STOL aircraft, neither Canada nor the United Kingdom would have led in this field of endeavour. (Hawker Siddeley wanted no competition from de Havilland for its own STOL aircraft which, however, never reached production.)

Many of the issues in which Investment Canada gets involved are of this sort. If the agency gives the right push, Canada might become a world leader; if it gives the wrong push, Canada may well disappear with respect to that activity.

I cannot, therefore, agree with those of my colleagues who hold the opinion that Investment Canada's role is marginal at best and harmful at worst. Governments throughout the world are engaged in a high-stakes strategic game. If we refuse to play, it is at our own risk. A small push by Investment Canada now can, as positive feedback theory shows, have enormous effects five to ten years down the line.

I will not go into the details here, but the twin examples of Connaught Laboratories and de Havilland aircraft underscore the importance and value of marginal intervention to alter the terms of a foreign takeover. Both foreign purchasers wanted the Canadian firms for their own particular purposes, which is why the Canadian firms were particularly valuable to them; more valuable, even, than they would have been if they were being operated successfully as stand-alone facilities. This gave Investment Canada room to manoeuvre. By imposing certain requirements the agency's purpose was to increase the chance of important spillovers staying in Canada. In neither case were Canadian innovators deprived of the market price for their efforts. No one knows what the effects of these interventions will be, but we cannot rule out the possibility that small decisions taken in Ottawa may have, as explained by positive feedback theory, enormous consequences for two Canadian industries five to ten years down the line.

I have tried to explain why the generalized neoclassical theories of economics may not always be the most useful guide for Investment Canada to follow with respect to many of the specific decisions it must make.

If the staff of Investment Canada expects more help from economic analysis, and hopes to see more economists on side (rather than off side, condemning what they see as yet another form of wasteful government intervention), then Investment Canada must specify more precisely the conditions under which it operates. It must tell economic theorists "this is the type of issue we decide" and "these are the sorts of circumstances under which we take our decisions". Economists are remarkably ingenious; given guidance in what to theorize about, they will theorize in highly relevant ways.

One notable aspect of this conference is that, when asked to consider a topic without constraints, the categories economists typically use are not those most relevant to the policy makers' specific situation. This should surprise no one. In order to receive useful theory, policy makers must guide economists by specifying their cases in more detail. This is particularly important if their approach is to be in line with the one I described briefly earlier, rather than neoclassical.

Over to Investment Canada! Before too long, let us have another conference at which we go beyond our present limits and we hear presentations of new theories formulated under more specific, policy-relevant, constraints.

ENDNOTES

1. The terminology of international issues seems to change every decade or so. I use the new term, *transnational corporation* (TNC), which has been endorsed by the United Nations as the successor to the more familiar term *multinational enterprise* (MNE).
2. In view of the reaction of an editor of mine who recently declared that anyone who would write so ungrammatical a title should not be taken seriously, I must point out the allusion in Reich's title is to the famous quotation from the comic strip Pogo: "We have seen the enemy and he is us!" The jist of his ariticle "Who is Us? has been incorporated in Chapter 25 of Reich, 1991.
3. Porter (1990) gives many reasons why this may be so, and cites many case studies where this seems to have been so. This issue is further discussed in a later section.
4. This point is not usually appreciated by those who advocate having "Canada owned by Canadians". An example may help: assume that 60 percent of the production of goods and services in each country is attributable to local firms servicing the domestic market, while 40 percent is attributable to TNCs serving the world market. This means that a typical country can expect to own the 60 percent of its capital that is devoted to domestic production alone, *plus its share* of the 40 percent owned by TNCs. Let the country's domestic output account for four percent of the world production of internationally traded commodities. If it owns *its share* of the

TNC capital involved in this production, it will own four percent of the TNC capital that is producing in its own country. It will also own four percent of the TNC capital that is producing in all other countries. This means that the country will own 61.6 percent of the total capital producing within its borders and foreigners will own 38.4 percent. In such a world, to insist that the majority of TNC production facilities located within Canada be owned in Canada, is to insist that Canada should own the majority of the world's TNC capital. The only other alternative is to insist that production in Canada be undertaken by domestically owned companies that are not TNCs, which would condemn Canada to inefficient local production of most of the commodities that are internationally traded elsewhere in the world.

5. This point seems to me to be extremely important because my reading of *Made in America*, (1988) is that many of the competitiveness problems of American firms can be explained by management decisions which,in retrospect, appear as management failures.
6. It seems to me that gross spillovers are what matter rather than the net spillovers that Bernstein studies.
7. There is substantial evidence that the cost of equity capital is substantially lower in Japan and Germany than in many other industrial countries, including Canada and the United States.
8. Porter found that the discount factor used to evaluate R&D is substantially higher in the United States than in any of the other nine countries he studied. He gives the following reasons (see pp. 110-113) which I summarize, not just to make the point, but to illustrate my earlier argument that it is unlikely that satisfactory explanations will emerge from aggregated or deinstitutionalized models. *Reasons for high discount rate in the United States:* (i) most shares are held by institutions, and these are evaluated on quarterly or annual share price appreciation; seeking to realize capital gains, institutions trade their shares frequently, and this is encouraged by low transactions costs in efficient U.S. markets; (ii) long-term capital gains being taxed at the same rate as income in the United States and nearly that high in Canada, shortens the time horizon of investment relative to countries where long-term capital gains go untaxed; (iii) shareholders have little say in management because boards play little role in influencing behaviour so that the takeover is the only way to discipline poorly performing management, and management is concerned with short-term, stock-price movements because of the ever-present takeover threat; (iv) executive compensation is correlated with size and usually involves a high bonus component related to this year's earnings; since executives do not stay long in one firm, they are unwilling to sacrifice this year's bonus for larger ones in the future. *Reasons for the lower discount rate in Germany and Switzerland:* (i) most shares are held by institutions but these hold them for long periods and rarely trade them; (ii) banks are large holders of equities and they play important roles on boards of directors, guiding investment plans; (iii) long-term capital

gains are exempt from taxation, leading to longer time horizons of investors; (iv) management responds to its board of directors, but is not particularly influenced by day-to-day movements in equity prices; (v) accounting practices allow the setting aside of large reserves to cushion low earning periods, so firms do not have to worry about short-term, short-falls in earnings; (vi) whether by custom, or as a rational response to these other factors, norms for reported profits are low; and (vii) many European countries have a much larger proportion of firms privately owned than does the United States and the goals of privately owned firms are more complex than mere profit maximization: "Often pride and the desire to provide continuity to employees is important. Private owners frequently have a very long time horizon, are intensely committed to the industry, and operate with different profitability thresholds. In our research, it was striking how many internationally successful companies were either privately held, effectively private because of a controlling or de facto controlling equity block, or owned by a nonprofit foundation. . . . The sustained investment of such companies and their close identification with and commitment to their industry were palpable." (Porter, 1991, p. 112)

9. This is the history of most attempts to extract empirically relevant predictions from pure economic theory. Given the very weak restrictions that economists are able to place on utility and production functions, it would be a miracle if their general theories could strongly restrict the universe of possible outcomes. In an earlier generation, Harry Johnson made a career out of showing that the restrictions economists thought they could put on possible outcomes were illusory and, given their assumptions, the result was that pretty well anything could happen. Interestingly, one of the cases he investigated was retaliation to the optimum tariff, where he demonstrated that, given asymmetries in offer curves, retaliation need not make both countries worse off. (For documentation of this general view see R.G. Lipsey, 1978.) A little methodological sophistication might curb extravagant expectations without having to disprove general claims in each case: just as economists have learned the lesson of JIJO — feed junk in and you will get junk out — they should finally learn the lesson of LILO — feed only a little in (by way of restrictions on parameters) and you will get only a little out (by way of restrictions on the universe of possible outcomes).
10. The three "runs" usually distinguished are (i) the short-run in which plant and equipment is fixed, (ii) the long-run in which all inputs including plant and equipment can be varied within the confines of given technology and (iii) the very-long-run during which technology can be varied.
11. "Japanese Woo Hi-tech Wizards", *The Globe and Mail*, November 12, 1990, p. B5.
12. See, for example, Hatsopolous (1988) for evidence with micro-explanations, and Federal Reserve Bank of New York (1989) for evidence with macro-explanations.

13. It should be apparent that my own view is much closer to what I call the business school-historical view, and the new theoretical view, than to the neoclassical view of the world. I am convinced that to understand the evolution of national comparative advantages, economic growth, and technology as they now exist in the world, economists must take into account forces that are now absent from price theory textbooks. I also believe, however, that theoretical constructs are necessary to understand the richer set of data with which we need to work, and that neoclassical economics, carefully used, still offers major insights. Thus, while wishing to make my own position clear, I want to avoid any doctrinal proselytizing or strife.
14. Most of what follows under the three following subheadings is taken from Dosi and Orsenigo (1988). Their views are typical of the views found in this branch of the literature.
15. Notice that the result of these characteristics is a permanent asymmetry among firms and countries in innovative capabilities, product technologies, input efficiencies, and resulting real incomes. The identity of individual countries in the pecking order may change, but the asymmetries persist; there is no tendency for a reduction in the degree of variance among real incomes of individual countries.
16. Dosi and Orsenigo give credit for establishing these important results to two authors: W. B. Arthur, *Competing Techniques and Lock-in by Historical Events: The Dynamics of Allocation Under Increasing Returns*, Stanford, Stanford University, CEPR, unpublished; and P. David, "Narrow Windows, Blind Giants and Angry Orphans: The Dynamics of Systems Rivalries and Dilemmas of Technology Policy", in F. Archangeli, P. David and G. Dosi (eds.), *The Diffusion of Innovation*, Oxford, Oxford University Press, 1988.
17. This point is discussed in some detail by Silverberg (1990).
18. This is a procedure pioneered by Nathan Rosenberg in his famous book *Inside the Black Box*, Cambridge, Cambridge University Press, 1982.

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